LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA14 | Newton Purcell to Brackley

Flood risk assessment (WR-003-014)

Water resources

November 2013

ES 3.5.2.14.14

VOL 5

LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA14 | Newton Purcell to Brackley

Flood risk assessment (WR-003-014)

Water resources

November 2013

ES 3.5.2.14.14

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

A report prepared for High Speed Two (HS2) Limited.

High Speed Two (HS2) Limited,
Eland House,
Bressenden Place,
London SW1E 5DU

Details of how to obtain further copies are available from HS2 Ltd.

Telephone: 020 7944 4908

General email enquiries: HS2enquiries@hs2.org.uk

Website: www.hs2.org.uk

High Speed Two (HS2) Limited has actively considered the needs of blind and partially sighted people in accessing this document. The text will be made available in full on the HS2 website. The text may be freely downloaded and translated by individuals or organisations for conversion into other accessible formats. If you have other needs in this regard please contact High Speed Two (HS2) Limited.

Printed in Great Britain on paper containing at least 75% recycled fibre.

Contents

List of figures

List of tables

1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise four parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Specific appendices for each community forum area (CFA) are also provided. For the Newton Purcell to Brackley area (CFA14) these are:

- a water resources assessment (Volume 5: Appendix WR-002-014);
- a flood risk assessment (i.e. this appendix); and
- a hydraulic modelling report for the River Great Ouse at Turweston (Volume 5: Appendix WR-004-005).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Scope of this assessment

1.2.1 This flood risk assessment (FRA) considers the assessment of flood risk in CFA14. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1] which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

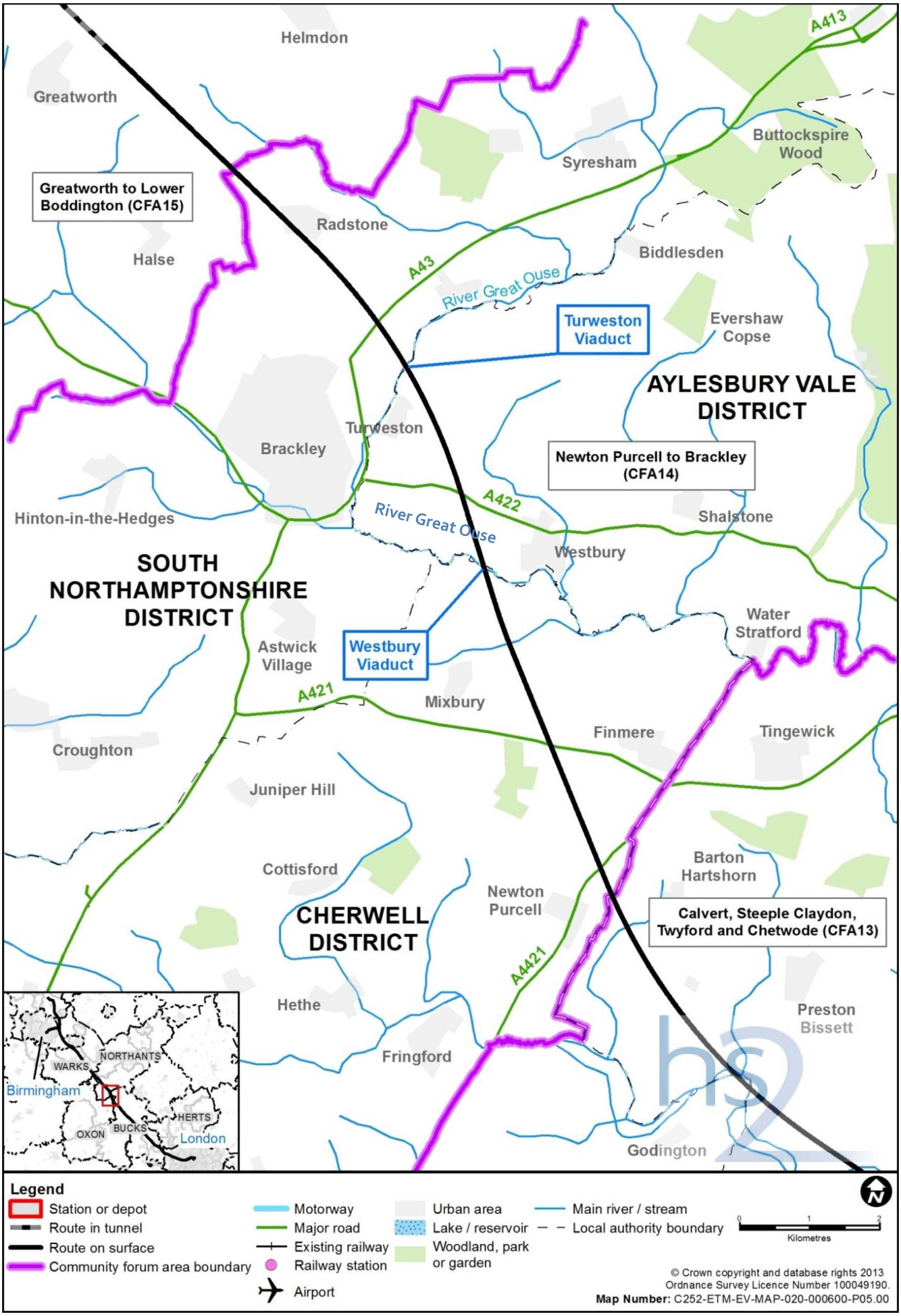
1.2.2 The FRA methodology and a review of the relevant local planning policy documents are provided in Section 2 of this report. The design criteria are provided in Section 3 and Section 4 documents the sources of information that have been reviewed. Section 5 provides a description of the planned works within CFA14. Section 6 considers baseline flood risk and the risk of flooding to the Proposed Scheme from all relevant sources. Flood risk mitigation measures included within the Proposed Scheme are detailed in Section 7. The effect of the Proposed Scheme on the risk of flooding is considered in Section 8.

1.3 Location

1.3.1 CFA14 covers an approximately 12km section of the Proposed Scheme within the districts of Cherwell, Aylesbury Vale and South Northamptonshire. It extends from the Buckinghamshire-Oxfordshire county boundary near Newton Purcell in the south, to the north of Brackley, as shown in Figure 1. The Calvert, Steeple Claydon, Twyford and Chetwode area (CFA13) and the Greatworth to Lower Boddington area (CFA15) lie to the south and north respectively.

[1] Department for Communities and Local Government (2012), *National Planning Policy Framework*.

Figure 1: Newton Purcell to Brackley area



1.3.2 The study area extends to a distance of 1km from the centre line of the route and includes the wards of Fringford (Cherwell), Little Brook, Brackley East and Astwell (South Northamptonshire) and Tingewick (Aylesbury Vale). It extends from the boundary between Barton Hartshorn and Newton Purcell with Shelswell parishes in the south-east to the intersection of Radstone and Greatworth parishes in the north-west.

1.3.3 The route will cross a number of primary watercourses within the study area, as identified using the surface water crossing (SWC) references on Map WR-01-020 and Map WR-01-021 (Volume 5, Water Resources and Flood Risk Assessment Map Book), including:

- tributaries of the Padbury Brook at Newton Purcell (SWC-CFA14-01 and SWC-CFA14-02);
- the tributary of the River Great Ouse at Mixbury (SWC-CFA14-03);
- the River Great Ouse at Westbury (SWC-CFA14-04) and Turweston (SWC-CFA14-05 and SWC-CFA14-06); and
- tributaries of the Radstone Brook (SWC-CFA14-07 to SWC-CFA14-09).

2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model individual sources of flooding within the study area are identified. The primary source of flooding is rainfall which is a direct source in the short-term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewer flooding) in the short- or medium-term. Stored rainfall, either naturally in belowground aquifers and natural lakes or artificially in impounded reservoirs and canals, can lead to flooding when the storage capacity of the system is exceeded. A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea.

2.1.2 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

2.1.3 Receptors considered in this assessment include the Proposed Scheme and existing development within 1km of the Proposed Scheme. The Proposed Scheme includes all associated permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified mitigation is proposed in line with recommendations in the NPPF.

2.1.4 Existing receptors within the study area are identified using Ordnance Survey (OS) mapping information. A high-level screening assessment is then undertaken to identify receptors that are within or in close proximity to an area of flood risk via pathways indicated using the flood risk data sources listed below. The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.5 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the Proposed Scheme has any potential to influence or alter the risk of flooding to each receptor. Where such potential has been identified, mitigation is proposed based on further analysis.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

[2] Department for Communities and Local Government (2012), *National Planning Policy Framework Technical Guidance.*

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	**Low**	**Medium**	**High**	**Very high**
Rivers		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water/overland flow	No surface water flooding.	Surface water flooding <0.3m for 1 in 200 years event.	Surface water flooding >0.3m for 1 in 200 years event; and Surface water flooding <0.3m for 1 in 30 years event.	Surface water flooding >0.3m for 1 in 30 years event.	
Groundwater		Very low-low	Moderate	High-very high	
Drainage and sewer systems	No sewer in vicinity of site.	Surcharge point >20m from site and no pathways.	Surcharge point within 20m of site and restricted pathways.	Sewer network crosses site and pathways exist.	
Artificial sources	Outside of inundation mapping/no pathway exists.	Within inundation mapping/ pathway exists.			

2.3 Regional and local flooding planning policy documents

2.3.1 The lead local flood authorities (LLFA) for CFA14 are Buckinghamshire County Council (BuCC), Oxfordshire County Council (OCC) and Northamptonshire County Council (NCC). The recommendations from the respective preliminary flood risk assessment (PFRA) reports undertaken in accordance with the Flood Risk Regulations 2009[3] have been reviewed in undertaking this assessment. BuCC and NCC have both published local flood risk management strategy (LFRMS) reports. The LFRMS for OCC, however, is still in development.

2.3.2 The local planning authorities for the study area are Aylesbury Vale District Council (AVDC), Cherwell District Council (CDC), and South Northamptonshire District Council (SNDC), currently part of the West Northamptonshire Joint Planning Unit (WNJPU).

2.3.3 The WNJPU was established to prepare joint development plan documents including the joint core strategy and strategic flood risk assessment (SFRA). The emergent joint core strategy is at the consultation draft stage.

[3] *Flood Risk Regulations 2009* (SI 2009 No.3042). London, Her Majesty's Station Office

Buckinghamshire County Council Preliminary Flood Risk Assessment

2.3.4 The BuCC PFRA[4] confirms that there are no indicative flood risk areas of national significance within the Buckinghamshire area. Consequently only Stage 1 of the Flood Risk Regulations 2009[5] process (i.e. the PFRA) has been completed.

2.3.5 The PFRA recognises that the construction and engineering of the Proposed Scheme may have a significant impact upon surface water flows. For example embankments and cuttings may, without suitable design solutions, impede the flow of small watercourses and surface water.

Buckinghamshire County Council Local Flood Risk Management Strategy

2.3.6 The BuCC LFRMS[6] guides the planning process in relation to flood risk across all categories. The LFRMS outlines key policies in relation to development within Buckinghamshire. Specific policies of relevance to the Proposed Scheme are:

- "Policy 6 – the LLFA will seek to reduce the risk of flooding now in a way which does not compromise the interconnected needs of the economy, society and environment in the future"; and
- "Policy 15 – sustainable drainage systems (SuDS) should be used in new developments to reduce the rate and volume of surface water. Design of SuDS to meet national standards and to be adopted by the SuDS Approval Body. SuDS are expected to provide natural removal of pollutants and sediments, promote aquifer recharge, enhanced biodiversity, add aesthetic value and be easily maintainable."

Oxfordshire County Council Preliminary Flood Risk Assessment

2.3.7 The OCC PFRA[7] confirms that there are no indicative flood risk areas of national significance within the Oxfordshire area. Consequently only Stage 1 of the Flood Risk Regulations 2009 process (i.e. the PFRA) has been completed. The PFRA indicates that groundwater and surface water are the major sources of flood risk (excluding rivers) within the county, although surface water flooding is noted to be of most concern within the urban centres.

2.3.8 The PFRA contains an overarching policy that seeks to ensure that development does not increase local flood risk. The guidance states that in exceptional circumstances flood risk can be increased contrary to Government policy where there are wider benefits. Any exceptions will not be expected to increase risk to levels which are significant in terms of Government criteria.

Northamptonshire County Council Preliminary Flood Risk Assessment

2.3.9 The NCC PFRA[8] confirms that there are no flood risk areas of national significance within Northamptonshire. Consequently only Stage 1 of the Flood Risk Regulations

[4] Jacobs (2011), *Buckinghamshire County Council Preliminary Flood Risk Assessment.*
[5] *Flood Risk Regulations 2009* (SI 2009 No. 3042), London, Her Majesty's Stationery Office.
[6] Buckinghamshire County Council (2013), *Buckinghamshire County Council Local Flood Risk Management Strategy 2013 – 2018.*
[7] JBA (2011), *Oxfordshire Preliminary Flood Risk Assessment.*
[8] Northamptonshire County Council (2011), *Northamptonshire Preliminary Flood Risk Assessment.*

2009 process (i.e. the PFRA) has been completed. The PFRA uses the Environment Agency Flood Map for Surface Water (FMfSW) and Environment Agency groundwater datasets to determine future flood risk in the county. No significant areas of flood risk (from non-river sources) were found within the Northamptonshire part of the study area.

Northamptonshire County Council Local Flood Risk Management Strategy

2.3.10 The NCC LFRMS[9] guides the planning process in relation to flood risk across all categories. Areas of particular interest are identified by assigning impact scores across a range of factors (health, social, economic, environment, infrastructure and psychology) for each flood source. The average impact score is used to assign a priority grading to each ward. All wards within the study area have been assigned low priority for groundwater flooding, with the exception of Little Brook, which has been assigned medium priority. For flooding from surface water, all wards have been assigned a high priority. All wards are assigned a low sensitivity to climate change in relation to both river and surface water flooding.

2.3.11 The LFRMS outlines key policies in relation to development within Northamptonshire. Specific policies of relevance to the Proposed Scheme are:

- Policy 1 – no culverting of watercourses without an overriding need to do so. Where possible, bridges and diversions are preferred. Where culverts are absolutely necessary, loss of habitat, pollution, changes in river morphology and loss of amenity space should be mitigated;
- Policy 2 – no introduction of water, increase in flow or flow volume to any watercourse, whether directly or indirectly. All collected surface water should be attenuated at source prior to discharge into local watercourses;
- Policy 4 – no diversion or obstruction of watercourses; and
- Policy 7 – no obstructions within 9m of the edge of any watercourse.

Great Ouse Catchment Flood Management Plan

2.3.12 The watercourses within CFA14 fall within the Great Ouse Catchment Flood Management Plan (CFMP)[10] which covers the risk extent from rivers of the Great Ouse basin. The rivers in the study area fall within the Bedford Ouse rural and eastern rivers policy area where Policy 3 is applied i.e. areas of low to moderate flood risk where the Environment Agency are generally managing existing flood risk effectively. The policy enables the lead local flood authorities (and Environment Agency, where appropriate) to continue to manage flooding through existing management actions.

Aylesbury Vale Water Cycle Strategy

2.3.13 The Aylesbury Vale Water Cycle Strategy[11] (WCS) reviews flood risk management planning policy relevant to Aylesbury Vale and outlines location specific concerns

---

[9] Northamptonshire County Council (2012), *Northamptonshire Local Flood Risk Management Strategy.*
[10] Environment Agency (2011), *Great Ouse Region Catchment Flood Management Plan.*
[11] Halcrow (2012), *Aylesbury Vale Water Cycle Strategy.*

regarding flood risk management. The WCS does not specifically cover any developments within the study area. The significant risks of river flooding along the Great Ouse valley, however, are noted. All proposed developments in the Aylesbury Vale area will require detailed drainage strategies and SuDS proposals including proposals outside of any identified flood risk area.

Aylesbury Vale Strategic Flood Risk Assessment

2.3.14 The Aylesbury Vale Level 1 SFRA[12] includes advice on planning policy within the development area and is often used as a basis for policy setting and planning decisions.

2.3.15 The Aylesbury Vale SFRA identifies the need for surface water management in the district due to concern over flooding within the Great Ouse valley downstream particularly at Buckingham. Infiltration based SuDS are preferred as a means of surface water management and ground investigations are required to determine the feasibility of such techniques. In addition opportunities are sought to enhance and supplement the existing flood storage and alleviation measures already in place for AVDC. The SFRA policy indicates that:

- management of surface water should use site specific and strategic SuDS measures encouraging source control where possible; and
- proposed infrastructure should avoid interference with floodplain flow and storage where they cross existing river valleys unless they are also specifically designed as part of the strategic flood risk management options. Consultation with the Environment Agency is essential in such cases.

Vale of Aylesbury Plan

2.3.16 The Vale of Aylesbury Plan[13] is in the consultation stage. Objective 7 which covers adaptation to and mitigation against climate change is of specific relevance to flood risk and development covering the following points:

- no built greenfield development to take place in the functional floodplain and/or Flood Zones 2 or 3, other than for essential strategic infrastructure; and
- improved flood protection including more effective use of multi-functional green spaces which can assist in flood control.

2.3.17 Policy VS11 sets out the position of AVDC towards protection of environmental assets, with a focus on maintaining watercourses and their settings for their biodiversity and recreational value, as well as incorporation of SuDS and flood storage areas to reduce downstream flood risk.

Cherwell and West Oxfordshire joint Strategic Flood Risk Assessment

2.3.18 The Cherwell and West Oxfordshire joint SFRA[14], released in 2009, promotes the use of SuDS to counteract the effects of climate change on the risk of flooding. Although

[12] Aylesbury Vale District Council (2012), *Aylesbury Vale Strategic Flood Risk Assessment*; Aylesbury Vale District Council (Revised from: Royal Haskoning (2007), *Aylesbury Vale SFRA*; Aylesbury Vale District Council).
[13] Aylesbury Vale District Council (2012), *Aylesbury Vale Level 1 Strategic Flood Risk Assessment for The Vale of Aylesbury Plan*.
[14] Jacobs (2008), Cherwell District *Strategic Flood Risk Assessment*.

acknowledged as a notable source of flooding in the district, the Great Ouse catchment is not covered in detail since the Cherwell has historically been the more significant source of flooding. Management of future flood risk is promoted through the protection of floodplains from development (with a specific reference to the use of level-for-level replacement floodplain storage where floodplain development is inevitable) and the restoration of river corridors. The Cherwell and West Oxfordshire joint SFRA recommends that strategic infrastructure is located within areas with the lowest risk of flooding.

Cherwell Local Plan

2.3.19 Although a non-statutory document, the 2011 Cherwell Local Plan[15] has been approved as interim planning policy for development control purposes. Policy EN12 of the non-statutory Cherwell Local Plan seeks to prevent development which will harm the quality of underground or surface water bodies. Cherwell Policy EN13 seeks to protect river corridors and watercourses. The intent of Cherwell Policy EN14 is to prevent development in areas at risk of flooding, whilst Policy EN15 seeks to limit the potential for surface water.

2.3.20 Overarching Policy ESD 1 of the CDC Local Plan (Proposed Submission Focus Document 2013) states that proposed development will be required to minimise the risk of flooding and make use of sustainable drainage methods. Policy ESD 6 expands on this to specifically promote SuDS and flood risk management through the protection of river corridors together with de-culverting and floodplain restoration. Specific guidelines for development are included as follows:

- "flood risk assessments should assess all sources of flood risk and demonstrate that there will be no increase in surface water discharge rates or volumes during storm events up to and including the 1 in 100 year storm event with an allowance for climate change (the design storm event)";
- "developments will not flood from surface water up to and including the design storm event or any surface water flooding beyond the 1 in 30 year storm event up to and including the design storm event will be safely contained on site"; and
- "development should be safe and remain operational (where necessary) and proposals should demonstrate that surface water will be managed effectively on site and that the development will not increase flood risk elsewhere, including sewer flooding".

2.3.21 Policies ESD 3 and ESD 7 promote source control and SuDS as a means to combat future increases in flood risk arising from climate change and as a proactive means of reducing downstream flood risk. Policy SLE 5, specific to the Proposed Scheme, states that "the design and construction of the High Speed 2 Rail Link must minimise adverse impacts on the environment [...] and maximise any benefits that arise from the proposal".

[15] Cherwell District Council (2011), *Cherwell Local Plan*.

West Northamptonshire Water Cycle Study

2.3.22 The West Northamptonshire WCS [16] reviews flood risk management options and establishes minimum design standards for new development. It is recommended that flood risk mitigation measures are applied on a strategic basis, with impacts elsewhere in the catchment of particular interest. For the Brackley area the recommended action for flood risk management is attenuation of surface water to reduce the risk of downstream flooding.

2.3.23 Surface water management strategies are recommended to apply the 'stormwater management train' which seeks firstly to prevent increased surface water (prevention), secondly to directly infiltrate or recycle (source control), thirdly to collect and control through attenuation or infiltration (site control), and finally to manage combined sites through major attenuation or wetlands (regional control). The WCS suggests that infiltration based SuDS systems are likely to be preferred around Brackley although the remainder of the region is likely to require surface attenuation due to high groundwater levels.

West Northamptonshire Strategic Flood Risk Assessment

2.3.24 The West Northamptonshire SFRA[17] includes advice on planning policy within the development area, and is often used as a basis for policy setting and planning decisions. SFRA policy indicates that:

- new development should not increase flood risk;
- surface water should be managed effectively on site; and
- development within Flood Zones should be safe.

2.3.25 It is specifically recommended that flood risk in the area should be managed by ensuring that development does not increase flood risk either upstream or downstream through increasing surface water, or construction which could impede flood water conveyance. Surface water management strategies incorporating SuDS are recommended for all developments as well as an assessment of the impact on groundwater levels.

West Northamptonshire Joint Core Strategy

2.3.26 The West Northamptonshire Joint Core Strategy[18] is in the final examination stage. Of relevance to flood risk and development are the following objectives:

- Objective 1 – to ensure development is located and designed so as to be resilient to future climate change and risk of flooding;
- Objective 14 – to protect and enhance existing green infrastructure and biodiversity corridors; and
- Objective 15 – to achieve high quality design that provides a safe, healthy and attractive environment.

---

[16] Halcrow (2009), *West Northamptonshire Water Cycle Study.*
[17] Scott Wilson (2009), *West Northamptonshire Strategic Flood Risk Assessment.*
[18] West Northamptonshire Joint Planning Unit (2013), *West Northamptonshire Joint Core Strategy.*

2.3.27 Policy C6 sets out the position regarding the Proposed Scheme indicating that the design and construction "must minimise adverse impacts on the environment" and "maximise any benefits that arise from the proposal".

2.3.28 General (i.e. not specific to the Proposed Scheme) Policy BN7 expands on the flood risk management objectives by requiring demonstration "that there is no increased risk of flooding to existing properties" and evidence that developments "seek to improve existing flood risk management". Additionally the policy states that any proposed surface water management systems should "be accompanied by a long-term management and maintenance plan" and "protect and enhance water quality".

3 Design criteria

3.1.1 It is a requirement of the design that the Proposed Scheme shall be protected against flooding from any source during the 1 in 1,000 years return period (0.1% annual probability) rainfall event with water levels not rising closer than 1m to the top of rail level.

3.1.2 In accordance with the NPPF an allowance for climate change is included in the assessment by assuming that peak rainfall intensity will increase by 30% and that peak river flows will increase by 20%.

4 Data sources

4.1 Primary Datasets

4.1.1 Consistent with the requirements of the NPPF, this assessment considers the risk of flooding from rivers, direct surface water runoff, rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

4.1.2 The Proposed Scheme lies entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

4.1.3 The primary datasets for each source of flooding used to assess the design elements are presented in Table 2. A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the line, further investigation in the form of hydraulic modelling is undertaken.

Table 2: Flood risk assessment data sources

Source of flooding	Datasets reviewed	Data owner
Rivers	Flood Zone mapping. Detailed River Network. Catchment hydraulic models.	Environment Agency
Surface water	Flood Map for Surface Water (FMfSW). Local surface water flood mapping.	Environment Agency LLFA
Groundwater	Areas susceptible to groundwater flooding. 1:50,000 geological mapping (superficial and bedrock). Potential for elevated groundwater.	British Geological Survey (BGS) LLFA
Drainage and sewer systems	Sewer network plans. Lost river location plans.	Water companies (various) Local planning authority
Artificial sources	Reservoir inundation mapping (RIM) Canal infrastructure locations. Trunk water main asset plans.	Environment Agency Canal & River Trust Water companies (various)

4.2 Site familiarisation visits

4.2.1 Due to land access restrictions no site familiarisation visits were undertaken within this study area.

5 The proposed development

5.1 Topography and land use

5.1.1 The land use within CFA14 is predominantly rural in character, comprising agriculture, with isolated farmsteads and villages. Brackley borders the western extent within the northern half of the study area.

5.1.2 The study area includes the villages of Newton Purcell, Mixbury, Westbury, Turweston and Radstone and the hamlet of Fulwell, as well as the north-eastern extents of the town of Brackley. The Proposed Scheme will cross the River Great Ouse at two locations.

5.2 Local flood risk receptors

5.2.1 The vulnerability of each local receptor with an identified pathway within the study area is presented in Table 3. The vulnerability is classified in accordance with the recommendations of Table 2 in the NPPF Technical Guidance Document and the Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-000/1) and the SMR Addendum (see Volume 5: Appendix CT-001-000/2).

Table 3: Vulnerability of local receptors in CFA14

Local receptor	Description	Vulnerability classification	Source/pathway
Newton Purcell	Residential and associated development	More vulnerable	Urban drainage
Station Road, Newton Purcell, including Shelswell Arms	Residential dwellings and drinking establishment	More vulnerable	Surface water 30 years - deep
Foxley Fields Farm	Residential dwelling and agriculture	More vulnerable	Groundwater - moderate
Finmere Quarry (Premier Aggregates Ltd)	Sand and gravel working	Water compatible	Groundwater - very high
Glebe Farm (Mixbury)	Residential dwelling and agriculture	More vulnerable	Surface water 30 years - deep
Mixbury	Residential dwelling and associated development	More vulnerable	Urban drainage
Fulwell House	Residential dwelling	More vulnerable	River flooding Flood Zone 2
Westbury	Residential dwellings and associated development	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - shallow Groundwater - very high
Grove Farm	Residential dwelling and agriculture	More vulnerable	Surface water 30 years - deep
Oatleys Farm	Residential dwelling and agriculture	More vulnerable	Surface water 30 years - deep Groundwater - moderate

Local receptor	Description	Vulnerability classification	Source/pathway
Oatleys Hall	Residential dwelling	More vulnerable	Groundwater - moderate
"Ballabeg" [Receptor to be demolished]	Residential dwelling and riding stables	More vulnerable	Surface water 30 years - deep
Turweston village	Residential dwelling and associated development	More vulnerable	Surface water 30 years - shallow Groundwater - very high
Turweston Mill	Residential dwelling	More vulnerable	River flooding Flood Zone 3 Surface water 200 years - shallow Groundwater - very high
Versions Farm	Residential dwelling and agriculture	More vulnerable	Groundwater - moderate
Whitfield Sewage Treatment Works	Sewage treatment works	Less vulnerable	River flooding Flood Zone 3 Surface water 200 years - shallow Groundwater - very high
Ilett's Farm [Receptor to be demolished]	Residential dwelling and agriculture	More vulnerable	Surface water 30 years - deep
Illett's Farm buildings off A43	Agricultural buildings	Less vulnerable	Surface water 200 years - shallow

5.3 Description of the Proposed Scheme

5.3.1 The Proposed Scheme through CFA14 will be approximately 12km in length, and will proceed north-west from the border between Buckinghamshire and Oxfordshire to the east of Newton Purcell CFA15, on the boundary of the Radstone and Greatworth Civil Parishes. The Proposed Scheme will pass between the villages of Newton Purcell, Finmere, Mixbury and Westbury, before skirting the eastern and northern boundaries of Brackley. Permanent construction features are shown on Map CT-06-060 to Map CT-06-068 (Volume 2, CFA14 Map Book).

5.3.2 The Proposed Scheme will leave the Calvert, Steeple Claydon, Twyford and Chetwode area (CFA13) in shallow cutting, proceeding to the east of Mixbury in a cutting approximately 4km long and up to 10m deep. Overbridges within this section include the realigned A4421 Buckingham Road, A421 London Road and Featherbed Lane overbridges, together with three public right of way (PRoW) overbridges and a private access accommodation overbridge. Noise and visual screening barriers will be included on the western side past the A4421 Buckingham Road and on the eastern side at the A421 London Road.

5.3.3 The route will continue into the Mixbury embankment and cutting section, comprising a 250m long embankment up to 8m high and a 500m cutting up to 8m deep. An overbridge will be required, a realignment of two bridleways. The route will then proceed into the Westbury viaduct and embankments section, comprising a 500m long embankment, a 300m long viaduct to span the River Great Ouse floodplain, and a 150m long embankment. Noise barriers will be included along the eastern side past Westbury, including along the northern extent of the viaduct.

5.3.4 The route will proceed into the 2km long Turweston cutting, which extends to south of the River Great Ouse near Turweston and will be up to 20m deep. The section will include the realigned A422 Brackley Road overbridge and two PRoW overbridges. Continuing into the Turweston viaduct, adjacent earthworks and Brackley south cutting section, the following 2.5km of the route will comprise an approximately 200m long embankment, approximately 80m long viaduct, approximately 600m long embankment and approximately 1.5km long cutting. The section will include two PRoW realignments, the A43 Oxford Road overbridge and two PRoW overbridges.

5.3.5 The route will continue into the Brackley north cutting section, which comprises an embankment approximately 200m long, followed by a cutting approximately 1.3km long and up to 8m deep. This section will include the realigned Radstone Road overbridge and a PRoW overbridge. The route will then continue northward into the Greatworth to Lower Boddington area (CFA15).

6 Existing flood risk

6.1 Historical flooding incidents

6.1.1 None of the PFRAs within this study area have identified past floods that have had significant harmful consequences, which would be reportable to the European Union.

6.1.2 The West Northamptonshire SFRA notes that Brackley has a history of flooding due to insufficient capacity within the urban drainage system. The Great Ouse valley was subject to a significant flood in 1875, with upstream Syresham particularly badly affected. Details of the extent of flooding at Turweston, Brackley and Westbury are not available for this event.

6.2 Risk of flooding from rivers

6.2.1 The Proposed Scheme will cross the River Great Ouse on viaduct at the Westbury viaduct west of Westbury (SWC-CFA14-04) and the Turweston viaduct north of Turweston (SWC-CFA14-05). A minor tributary stream of the River Great Ouse will be crossed by the Mixbury embankment east of Mixbury (SWC-CFA14-03), with the watercourse conveyed within a culvert (Mixbury culvert). Other minor watercourses within the study area are considered alongside the risk of surface water flooding in Section 6.3.

Mixbury

6.2.2 The River Great Ouse tributary stream at Mixbury flows in a north-easterly direction within a steep well defined valley towards the River Great Ouse which it joins at Fulwell. The Proposed Scheme will cross the stream on embankment with a culvert to convey flood flows as shown on Map WR-01-020, D5 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The embankment will occupy approximately 1,200m^2 of both Flood Zones and will be perpendicular to the natural flow direction. At the proposed crossing location the stream has a catchment size of 3km^2 with a relatively low estimated 1 in 100 years return period (1% annual probability) flood flows of approximately 0.2m^3/s due to the highly permeable nature of the subsoil. The Mixbury embankment design element will be at risk of flooding.

Flood risk to the Proposed Scheme

6.2.3 Comparison of the Flood Zone outlines with light detection and ranging (LiDAR) information suggests a 1 in 1,000 years return period (0.1% annual probability) flood water level, at the proposed crossing location, of no more than 105m above Ordnance Datum (AOD). The minimum top of rail level will be 111.2m AOD, resulting in a minimum freeboard of just over 6m between the 1 in 1,000 years return period (0.1% annual probability) flood water level and the top of rail level (low risk).

River Great Ouse at Westbury

6.2.4 The Proposed Scheme will cross the River Great Ouse, as shown on Map WR-01-020, C5 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The full extent of the Flood Zones will be spanned on viaduct upstream of the village of Westbury, with the proposed viaduct skewed at approximately 20° relative to the floodplain flow

direction. At the crossing location, the River Great Ouse has a catchment size of approximately 77km^2, resulting in an estimated 1 in 100 years return period (1% annual probability) flood flows of 25m^3/s, calculated using the Revitalised Flood Hydrograph (ReFH) rainfall-runoff modelling methodology. The viaduct will cross approximately 230m of Flood Zone 3 and 260m of Flood Zone 2. The Westbury viaduct design element will be at risk of flooding.

Flood risk to the Proposed Scheme

6.2.5 The Environment Agency has provided the output results of the Upper Great Ouse Flood Hazard Mapping study, a detailed hydrodynamically linked one-dimensional channel and two-dimensional floodplain model completed in June 2011.

6.2.6 The baseline estimates of maximum flood water levels along the extent of the viaduct are presented in Table 4. The viaduct crosses the floodplain at an angle of approximately 20°, and is 300m in length. At this location, the river channel is at the southern extent of the floodplain. Due to the skewed crossing angle and viaduct length, the northern extent of the viaduct within the floodplain area is approximately 180m upstream of the southern extent of the viaduct. As a result, predicted flood water levels are higher in the floodplain at the northern extent of the viaduct length by between 100mm and 150mm relative to the flood level at the proposed channel crossing to the south.

Table 4: River Great Ouse at Westbury model details

	100 years return period	**100 years return period including climate change**	**1,000 years return period**
Peak channel flow	23.4m^3/s	24.0m^3/s	25.3m^3/s
Peak channel flood level	96.39m AOD	96.44m AOD	96.50m AOD
Peak floodplain flood level	96.51m AOD	96.58m AOD	96.65m AOD

6.2.7 The minimum top of rail level along the Westbury viaduct will be 107.4m AOD at the proposed channel crossing. The top of rail rises to a level at the southern viaduct extent of 107.5m AOD, and at the northern extent of 107.8m AOD. There will therefore be a minimum freeboard between the Proposed Scheme and the predicted 1 in 1,000 years return period (0.1% annual probability) flood water level of 1 0.9m at the channel. The risk of river flooding at Westbury viaduct to the operational portion of the Proposed Scheme will be less than 0.1% (low risk).

River Great Ouse at Turweston

6.2.8 The Proposed Scheme will cross the River Great Ouse immediately upstream of the village of Turweston, as shown on Map WR-01-021, F6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). At the crossing location, the River Great Ouse has a catchment size of approximately 38km^2, resulting in an estimated 1 in 100 years return period (1% annual probability) flood flows of 20m^3/s, calculated using ReFH rainfall-runoff modelling methodology. Approximately 50m upstream of the Proposed

Scheme the river splits to form the mill stream for Turweston Mill 350m downstream. The level in the millstream is controlled by a weir on the natural channel, which is located approximately 5m upstream of the proposed viaduct.

6.2.9 The Proposed Scheme will cross approximately 80m of both Flood Zones on viaduct, with the approach embankments occupying approximately 1,300m^2 of Flood Zone 3 and 2,000m^2 of Flood Zone 2. Design elements that will lie within the area at risk of flooding are Turweston embankment, Turweston viaduct and Helmdon embankment. In addition, the realigned Footpath TUW/7 will pass beneath the Turweston viaduct around the foot of the Turweston embankment and diverted realigned Footpath BD8 will pass beneath the Turweston viaduct around the foot of the Helmdon embankment. Both footpaths, formerly outside of the area at risk of flooding, will pass through Flood Zone 3.

Flood risk to the Proposed Scheme

6.2.10 The Environment Agency has provided the output results of the Upper Great Ouse Flood Hazard Mapping study, a detailed hydrodynamically linked channel (one-dimensional) and floodplain (two-dimensional) model completed in June 2011.

6.2.11 The baseline estimates of maximum flood water levels along the extent of the viaduct are presented in Table 5. Due to the proximity of the Proposed Scheme to the channel bifurcation, predicted flood levels between the two branches of the river are similar, with a maximum variance of 50mm. Flood water levels between the two branches are closely related to the water levels in the natural channel, which carries the majority of the flow.

6.2.12 According to the two-dimensional model results, including the floodplain flow vectors, interaction between the two channels is limited for all design flood events, with all significant interactions occurring downstream of the Proposed Scheme.

Table 5: River Great Ouse at Turweston model details

	100 years return period	**100 years return period including climate change**	**1,000 years return period**
Peak channel flow	18.5m^3/s	20.4m^3/s	22.9m^3/s
Peak millstream flow	4.9m^3/s	6.2m^3/s	8.3m^3/s
Peak channel flood level	105.85m AOD	105.93m AOD	106.03m AOD
Peak millstream flood level	105.90m AOD	105.98m AOD	106.07m AOD
Peak floodplain flood level	105.85m AOD	105.91m AOD	106.04m AOD

6.2.13 The minimum top of rail level within the floodplain will be 114.4m AOD at the southern extent of the floodplain. There will therefore be a minimum freeboard between the Proposed Scheme and the predicted 1 in 1,000 years return period (0.1% annual probability) flood water level of 8.3m at the millstream crossing. The risk of river flooding at Turweston viaduct to the operational portion of the Proposed Scheme will be less than 0.1% (low risk).

6.2.14 The realigned footpaths will be at risk of flooding following completion of the Proposed Scheme. The proposed new route of Footpath TUW/7 (Promoted PRoW) around the southern approach embankment will pass through flood waters with a depth of up to 1.2m in the 1 in 1,000 years return period (0.1% annual probability) flood event, with flow velocities up to 0.6m/s according to the modelling results. Applying a debris factor of 0.5 (recommended for depths of over 0.75m within arable/pasture land[19]), the peak hazard rating on the footpath is 1.82, "danger for most". The corresponding values for the 1 in 100 years return period (1% annual probability) flood event are a maximum depth of 1.1m, peak velocity of 0.5m/s and a peak hazard rating of 1.60, "danger for most". The peak velocity and peak depth are, however, unlikely to occur at the same time, and the calculated peak hazard ratings (taken from the time-varying model results) are lower, at 0.72 and 0.62 respectively, both falling below the 0.75 threshold for "danger for some". Further, the highest depths and velocities along the line of the diverted footpath occur within the millstream channel, which is to be diverted to create the necessary space for the footpath. The peak hazard rating along the line of the footpath diversion away from the millstream channel is 0.47 in the 1 in 1,000 years return period (0.1% annual probability) flood event ("very low hazard").

6.2.15 Similarly, the proposed new route of Footpath BD8 around the northern approach embankment will pass through the Flood Zones. In the 1 in 1,000 years return period (0.1% annual probability) flood event, the peak flood depth along the line of the proposed diversion is 0.73m, and the peak velocity is 1.1m/s. Since the depth will be less than 0.75m, the recommended debris factor is zero, and the corresponding peak hazard rating is 1.17, "Danger for some". Again, as with Footpath TUW/7 above, the peak velocity and depth are unlikely to occur simultaneously, and the time-varying results suggest a peak hazard rating of 0.57 (below the threshold for "danger for some") in the 1 in 1,000 years return period (0.1% annual probability) flood event. Corresponding hazard ratings for the 1 in 100 years return period (1% annual probability) flood event including an allowance for climate change is 0.43.

6.3 Risk of flooding from surface water

6.3.1 There are areas of flood risk shown on the FMfSW associated with the River Great Ouse and the Mixbury tributary stream. In all cases the extents of flooding are within the extents of flooding from rivers for the watercourses and, since flooding from direct surface water runoff occurs early in any given rainfall event, are likely to have receded prior to the onset of any significant flooding from the watercourses. On this basis, there is unlikely to be any significant cumulative effect due to combined flooding from direct runoff and from the watercourse that would not already be accounted for in the flood risk from rivers analysis discussed previously. As a result, flood risk from the rivers will be the dominant source of flood risk to the Proposed Scheme, with additional effects from direct runoff likely to be negligible and therefore not assessed further in this section. Other areas with risks of flooding from surface water runoff are considered below.

[19] FD2321/TR2 Table 3.1 (Department for Environment, Food and Rural Affairs R&D Outputs: Flood Risks to People Phase 2 – Guidance Paper, Guidance Note 3)

Newton Purcell

6.3.2 Close to the southern extent of CFA14 near to Newton Purcell, the Proposed Scheme will pass alongside the valley of a tributary stream to the Padbury Brook, crossing the line of the watercourse (SWC-CFA14-01) at two locations, as shown on Map WR-01-020, H6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). Due to the presence of the existing railway embankment, the Proposed Scheme lies partially within the area shown to be at risk of shallow flooding (100mm to 300mm depth) in the 1 in 30 years return period (3.3% annual probability) event, and watercourse culverts are already in place. In contrast, the Proposed Scheme will be in cutting through the area. At the upstream (northern) crossing (SWC-CFA14-02), there is a confluence between two branches of the stream, with watercourses and associated surface water risk areas present on both sides of the Proposed Scheme. The A4421 Buckingham Road overbridge embankments will therefore cross both of these channels and associated areas of risk. Noise barriers along the west side of the Proposed Scheme and north of Station Road will also cross the watercourse and risk area. Design elements that lie within the area of risk are the Barton to Mixbury cutting and the A4421 Buckingham Road overbridge.

6.3.3 Comparison of the FMfSW outlines with LiDAR information suggests a 1 in 200 years return period (0.5% annual probability) flood levels of 105m AOD rising to 107m AOD at Station Road on the west side of the Proposed Scheme, and 108m AOD on Station Road on the east side of the Proposed Scheme. At the A4421 Buckingham Road overbridge, estimated flood levels are 108m AOD on the western branch of the stream and 110m AOD on the eastern branch. Top of rail level heights along the Barton to Mixbury cutting rise within the flood risk area from 105.2m AOD to 105.8m AOD at Station Road. The top of rail level will therefore be below the estimated flood water level throughout the majority of the risk area.

6.3.4 The Proposed Scheme includes allowance for overland surface water flows to be collected into land drainage, in this area to include diversions of the existing watercourses along both sides of the Proposed Scheme, before passing to the east side of the Proposed Scheme close to the current embankment culvert, in a drop inlet culvert of 1350mm diameter. The culvert will be designed to convey the estimated 1 in 100 years return period (1% annual probability) flood flow including an allowance for climate change, siltation and blockage. The diverted watercourse channels will be designed with sufficient capacity for the estimated 1 in 100 years return period (1% annual probability) flood flow including an allowance for climate change.

6.3.5 The FMfSW shows the extent of flooding due to rainfall that would occur prior to collection of water into streams of designated drainage infrastructure. By collecting the flows from the watercourses and valley floodplains into an adequately designed land drainage system, the Proposed Scheme will effectively remove the risk of surface water flooding from the point at which the flow would be intercepted for all return period events up to and including 100 years (>1% annual probability). There is a residual risk of the cut-off drain overtopping in more extreme events and the risk of flooding to the Barton to Mixbury cutting is considered to be 'low risk'.

6.3.6 The A4421 Buckingham Road overbridge will cross both arms of the tributary stream and associated valleys. The streams will be conveyed beneath the overbridge embankments in 1200mm precast concrete box culverts, designed to adequately convey the 1 in 100 years return period (1% annual probability) return period flood flows including allowances for climate change, siltation and blockage. The approach embankments will be raised above surrounding ground in order to pass over the Proposed Scheme at a level of 115.9m AOD. The road level at the western approach embankment crossing will be 116.4m AOD whilst at the eastern crossing the road level will be at 113.6m AOD, at least 8.4m and 3.6m above the estimated 1 in 200 years return period (0.5% annual probability) flood water levels (no risk).

Finmere Quarry

6.3.7 There are a number of large areas around Finmere Quarry shown on the FMfSW to be at risk of deep (>300mm) surface water ponding during both the 1 in 200 years return period (0.5% annual probability) and 1 in 30 years return period (3.3% annual probability) rainfall events, as shown on Map WR-01-020, F6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The Barton to Mixbury cutting will pass through the areas shown to be at risk. The LiDAR in this area is patchy, and considered unreliable due to the quarrying activities, as well as the thick forestry plantations. OS information suggests that the area is relatively flat, with the exception of the quarry workings. The general flow direction along the line of the Proposed Scheme appears to be from west to east, towards the Radstone Brook, however much of the land to the east of Widmore Farm appears to drain along a dry valley in a south-easterly direction away from the stream towards Shelswell. The FEH CD-ROM shows the catchment watershed to lie roughly parallel to the Proposed Scheme and approximately 300m to the west. Although localised variations are possible, catchment sizes for the areas of ponding shown on the FMfSW will be extremely low, and surface water will be collected and discharged in the formal land drainage system associated with the Proposed Scheme, thus removing the potential for flooding from this source.

Westbury dry valley

6.3.8 Approximately 400m south of the Westbury viaduct, the Proposed Scheme will cross a dry valley that passes in a north-easterly direction towards the River Great Ouse, as shown on Map WR-01-020, C5 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The base of the dry valley is shown to be at risk of shallow (<0.3m depth) surface water flooding in the 1 in 200 years return period (0.5% annual probability) rainfall event, with ponding occurring behind the disused railway embankment, which disrupts flood flows towards the base of the Great Ouse valley. The Westbury embankment and a maintenance access track to the balancing ponds at Westbury viaduct are at risk of surface water flooding. A land drain is proposed along the base of the combined embankments, discharging to the River Great Ouse just upstream of the Westbury viaduct.

6.3.9 Comparison of the FMfSW outline with LiDAR data for the area suggests a maximum flood water level at the upstream intersection with the Proposed Scheme of 107.5m AOD. The top of rail will be at a level of 108.5m AOD, 1m above the estimated flood

water level (no risk). The access road will be at existing ground levels and will therefore be at risk of shallow flooding. The overland flows will be intercepted by the proposed land drainage, which will be designed with sufficient capacity to contain the 1 in 100 years return period (1% annual probability) design flood including an allowance for climate change. There will therefore be no significant risk of flooding to the Proposed Scheme.

Turweston Mill tributaries

6.3.10 To the north of Turweston, the Proposed Scheme will cross two dry valleys which flow from east to west towards the floodplain of the River Great Ouse, as shown on Map WR-01-021, F6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The southern dry valley joins the floodplain at Turweston Mill, and there is a narrow band at risk of shallow (100mm to 300mm in depth) flooding in the 1 in 200 years return period (0.5% annual probability) rainfall event. The northern dry valley joins the floodplain of the River Great Ouse immediately downstream of the Proposed Scheme, with areas shown on the FMfSW to be at risk of shallow (100mm to 300mm in depth) flooding in both the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events. The Turweston cutting and Turweston embankment design elements lie within the areas at risk of flooding at the southern and northern dry valleys respectively.

6.3.11 The Proposed Scheme will be in cutting approximately 7m deep through the area at risk at the southern dry valley, and there is therefore a risk of flooding to the Proposed Scheme. Surface water runoff will be collected within the land drainage of the Proposed Scheme along the east side, discharging via a balancing pond to the River Great Ouse upstream of Turweston viaduct. All land drainage elements will be designed with sufficient capacity to convey the 1 in 100 year return period (1% annual probability) rainfall event including allowances for climate change, blockage and siltation.

6.3.12 The FMfSW shows the extent of flooding due to rainfall that would occur prior to collection of water into streams or designated drainage infrastructure. By collecting the flows from the dry valley into an adequately designed land drainage system, the Proposed Scheme will effectively remove the risk of surface water flooding from the point at which the flow would be intercepted for all return period events up to and including 100 years (>1% annual probability rainfall events) including an allowance for climate change. There is a residual risk of the cut-off drain overtopping in more extreme events.

6.3.13 Comparison of the FMfSW extents at the northern dry valley with LiDAR information suggests a maximum flood water level in the 1 in 200 years return period (0.5% annual probability) event of 109m AOD at the intersection with the Proposed Scheme. The top of rail at the dry valley crossing will be at a level of 114.4m AOD, at least 5m above the predicted flood water level. An access road is proposed on the east side of the Proposed Scheme to service balancing ponds, which will cross the area at risk at existing ground levels and is therefore at risk of shallow flooding. There is a land drain proposed on the upstream side of the access road which will intercept surface water runoff, discharging via a balancing pond to the River Great Ouse upstream of

Turweston viaduct. By collecting the flows from the dry valley into an adequately designed land drainage system, the Proposed Scheme will effectively remove the risk of surface water flooding from the point at which the flow would be intercepted for all return period events up to and including 100 years (>1% annual probability rainfall events) including an allowance for climate change.

Northampton Road

6.3.14 The Proposed Scheme will cross a dry valley at Ilett's Farm, on the north side of the A43 Northampton Road (SWC-CFA14-15), as shown on Map WR-01-021, F6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The raised A43 road embankment will result in ponding on the upstream side, shown as areas of deep (greater than 300mm) flooding on the FMfSW in both the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events. The Proposed Scheme will be in cutting through the area shown to be at risk and there is therefore potentially a risk of flooding to the Proposed Scheme. The Brackley south cutting and Northampton Road overbridge are at risk of surface water flooding.

6.3.15 Comparison of the FMfSW extents with LiDAR information suggests a maximum flood water level in the 1 in 200 years return period (0.5% annual probability) rainfall event of 129m AOD immediately upstream of Northampton Road rising to 135m AOD at the northern extent of the dry valley crossing. The estimated flood water level at the proposed new Northampton Road overbridge is 131m AOD. The Proposed Scheme top of rail will be at a level of 122.1m AOD at the current location of Northampton Road, rising to 125.1m AOD at the northern extent of the risk area.

6.3.16 The Proposed Scheme will be in cutting a minimum of 5m deep through the area at risk, and there is therefore a risk of flooding to the Proposed Scheme. Surface water runoff will be collected within the land drainage along both sides of the Proposed Scheme. The east side land drainage will discharge directly to the River Great Ouse upstream of Turweston viaduct, with the west side land drainage discharging via a balancing pond to the River Great Ouse downstream of Turweston viaduct. All land drainage elements will be designed with sufficient capacity to convey the 1 in 100 year return period (1% annual probability) rainfall event including allowances for climate change, blockage and siltation.

6.3.17 The Northampton Road overbridge will be at a minimum level of 131.9m AOD within the area of flood risk, so there will therefore be a minimum freeboard for the road level at the overbridge of 0.9m AOD for the 1 in 200 years return period (0.5% annual probability) flood event. There will be no significant risk of flooding to the realigned road or overbridge.

6.3.18 The southern approach embankment of the Northampton Road overbridge will cross a partially culverted tributary stream of the River Great Ouse at its far southern extent. The valley is relatively steep sided, however there is a significant area along the base of the valley shown to be at risk of deep (greater than 300mm) flooding in both the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events, the severity compounded by backing up behind the culvert beneath the existing Northampton Road.

6.3.19 Comparison of the FMfSW extents with LiDAR information suggests a maximum flood water level in the 1 in 200 years return period (0.5% annual probability) rainfall event of 118m AOD at the Northampton Road crossing. The road will be at a minimum level of 123.3m AOD within the area at risk, and therefore at least 5m above the potential flood water level. There will be no significant risk from this source to the Northampton Road overbridge.

Radstone south watercourses

6.3.20 South of Radstone, the Proposed Scheme will cross a watercourse (SWC-CFA14-07) and dry valley, as shown on Map WR-01-021, D6 (Volume 5, Water Resources and Flood Risk Assessment Map Book) with associated areas at risk of shallow (100mm to 300mm) surface water flooding shown on the FMfSW in both the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events. The Proposed Scheme will be on embankment at the watercourse crossing, but will be in cutting at the dry valley (approximately 300m to the south-east). Design elements within the area at risk are the Brackley embankment and Brackley south cutting, as well as the PRoW AX15 overbridge (at the dry valley) and Radstone Road overbridge at the watercourse crossing.

6.3.21 Comparison of the FMfSW with LiDAR information suggests flood water levels of around 138m AOD at the watercourse crossing and 139m AOD at the dry valley crossing. The Proposed Scheme top of rail level at the watercourse crossing will be a minimum of 139.0m AOD, a minimum of 1m above the predicted flood water level. The road level of the Radstone Road overbridge will be a minimum of 140.2m AOD within the area at risk at the watercourse crossing, and there will therefore be a minimum freeboard between the predicted flood water level and the road level. Neither element will be at significant risk of flooding from surface water within the valley associated with the watercourse. There is an access track from Radstone Road proposed to service some balancing ponds on the west side of the Proposed Scheme, which will cross the watercourse valley upstream of Radstone Road, and there is consequently a potential risk of flooding. The stream will pass beneath the access road within a culvert designed to convey the 1 in 100 years return period (1% annual probability) design event including an allowance for climate change.

6.3.22 Although the Proposed Scheme will be in cutting through the area shown to be at risk at the dry valley, surface water will be collected into the proposed land drainage and discharged to the northern watercourse via a balancing pond. The land drainage infrastructure will be designed with sufficient capacity to convey the 1 in 100 years return period (1% annual probability) rainfall event, including an allowance for climate change, siltation and blockage.

6.3.23 The FMfSW shows the extent of flooding due to rainfall that would occur prior to collection of water into streams or designated drainage infrastructure. By collecting the flows from the dry valley into an adequately designed land drainage system, the Proposed Scheme will remove the risk of surface water flooding from the point at which the flow would be intercepted for all return period events up to and including 100 years (>1% annual probability rainfall events) including an allowance for climate change. There will be mitigation bunding between the land drainage and the cutting,

which will prevent any flood water overtopping into the cutting should the capacity of the land drainage be exceeded during more severe events. The PRoW AX15 overbridge will be a minimum level of 142.2m AOD within the area at risk, and will therefore be at least 3.2m above the predicted flood water level. There will therefore be no significant risk of flooding to the Proposed Scheme at the dry valley.

Radstone central watercourse

6.3.24 To the north-west of Radstone, the Proposed Scheme will cross a further tributary of the Radstone Brook (SWC-CFA14-08), as shown on Map WR-01-021, C6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The FMfSW shows a risk of surface water flooding in the 1 in 200 years return period (0.5% annual probability) rainfall event, of between 100mm and 300mm depth. The Proposed Scheme will be in cutting approximately 2.5m deep at this location, part of the Brackley north cutting design element.

6.3.25 Although the Proposed Scheme will be in cutting through the area shown to be at risk, the watercourse in question will be diverted north to the watercourse on the boundary of CFA15. All surface water will be collected into the diverted watercourse and discharged via a balancing pond. The land drainage infrastructure will be designed with sufficient capacity to convey the 1 in 100 years return period (1% annual probability) rainfall event including an allowance for climate change, siltation and blockage. There will therefore be no significant risk of flooding to the Proposed Scheme at this location.

Radstone north watercourses

6.3.26 At the northern extent of CFA14, along the boundary with CFA15, the Proposed Scheme will cross a small watercourse (SWC-CFA14-09) and dry valley to the north, as shown on Map WR-01-021, B6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The FMfSW shows surface water flooding greater than 300mm deep in the 1 in 30 years return period (3.3% annual probability) rainfall event at the watercourse crossing. The Greatworth south embankment is the only element within CFA14 that will be at risk of flooding.

6.3.27 The Proposed Scheme will be on a low embankment at the watercourse crossing. The surrounding ground level is approximately 148m AOD. The top of rail level at the watercourse crossing will be 150.5m AOD, more than 2m above ground levels. Comparison of the 100mm and 300mm FMfSW outlines with ground levels suggests a 1 in 200 years return period (0.5% annual probability) flood level of no more than 148.3m AOD. There will therefore be a freeboard of at least 2.2m for the minimum top of rail level at the watercourse crossing for the 1 in 200 years return period (0.5% annual probability) flood event.

6.4 Risk of flooding from groundwater

6.4.1 The combined information from the relevant PFRA and SFRA reports indicates that the risk of groundwater flooding within CFA14 is generally low. The BGS dataset indicates that the Proposed Scheme will intersect areas of 'moderate' to 'very high' susceptibility to flooding from groundwater at the following locations:

- an area of 'moderate' to 'high' susceptibility within the superficial sand and gravel deposits around Finmere Quarry, south-west of Finmere;
- areas of 'very high' susceptibility within the alluvium along the River Great Ouse valley and the tributary stream at Mixbury;
- additional areas of 'moderate' to 'high' susceptibility from the outcropping bedrock aquifers of the Great Oolite Group (specifically, Taynton Limestone (Principal), Sharp's Hill Beds (Secondary A) and Horsehay Sand Formation (Secondary A)) along the sides of the River Great Ouse valley at Turweston;
- areas of 'high' and 'very high' susceptibility within superficial diamicton deposits along the stream valley and dry valley south of Radstone; and
- areas of 'high' and 'very high' susceptibility within the superficial diamicton deposits south of Halse Copse on the boundary of the study area with CFA15.

6.4.2 For there to be a risk of flooding from groundwater, the relevant receptor needs to be below ground or at the surface. Consequently, where the Proposed Scheme will be raised above surrounding ground, either on embankment or viaduct, the risk of flooding from groundwater is negligible. The only element of the Proposed Scheme that will be in cutting through an area at potential risk of groundwater flooding is the Barton to Mixbury cutting, at Finmere Quarry.

Finmere Quarry

6.4.3 The Barton to Mixbury cutting will be between 5m and 8m deep through the area shown to be susceptible to groundwater flooding near Finmere Quarry south-west of Finmere. As described in Volume 5: Appendix WR-002-014 the cutting will pass through the superficial deposits into the Forest Marble formation below which is a principal aquifer. Although classified on the BGS groundwater susceptibility dataset as arising from superficial deposits the area at risk appears to coincide with the extent of the Forest Marble and it is therefore likely that the risk of flooding arises either directly, or through hydraulic continuity with the surface deposits, from the bedrock aquifer. The cutting will potentially intercept groundwater with a consequent risk of groundwater flooding to the Proposed Scheme.

Deep Cuttings

6.4.4 As described in Volume 5: Appendix WR-002-014 there are a number of deep cuttings proposed within CFA14 which have the potential to intercept groundwater flows despite not falling within areas shown to be at risk of flooding from groundwater on the BGS dataset, which assesses groundwater emergence at the surface only. Such cuttings will potentially be flooded during times of high groundwater. Though emergent groundwater will be collected into the track drainage, there is potential for surface ponding within the cuttings depending on the cutting depth and aquifer levels. Design elements within CFA14 that may be at risk of flooding due to below-ground construction within water-bearing strata are:

- the Barton to Mixbury cutting where it passes through the Cornbrash Limestone (Secondary A aquifer);
- the southern extent of the Turweston Cutting where it is deepest, reaching to

the base of the Horsehay Sandstone Formation - a Secondary A aquifer; and

- the Brackley south cutting where it passes through the Blisworth Limestone Formation- a Principal aquifer.

6.5 Risk of flooding from drainage systems

6.5.1 The Proposed Scheme will not pass through any urban areas for the full extent within CFA14. There will consequently be no significant risk of flooding from urban drainage within the study area.

6.6 Risk of flooding from artificial sources

6.6.1 The Proposed Scheme will not cross any areas shown on the Environment Agency RIM to be at risk of flooding in the event of impounded reservoir failure within CFA14. No further artificial water bodies were identified within the study area that will constitute a significant risk of flooding to the Proposed Scheme.

6.7 Summary of baseline flood risk

Table 6: Summary of baseline flood risk for all sources of flooding in CFA14

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
River	Great Ouse Tributary at Mixbury	Very High Flood Zone 3b	Mixbury embankment	Top of rail level will be >1m above 1,000 years return period water level.
River	Great Ouse at Westbury	Very High Flood Zone3b	Westbury viaduct	Top of rail level will be >1m above 1,000 years return period water level.
River	Great Ouse at Turweston	Very High Flood Zone 3b	Turweston embankment	Top of rail level will be >1m above 1,000 years return period water level.
			Turweston viaduct	
			Helmdon embankment	
		High Flood Zone 3	Footpath TUW/7	Maximum possible hazard rating of 1.60 'Danger for Most', though modelled rating is lower at 0.62, low risk.
		High Flood Zone 3	Footpath BD8	Maximum hazard rating of 0.94 'Danger for Some', though modelled rating is lower at 0.43, low risk.
Surface water	Newton Purcell	Medium 30 years FMfSW <0.3m	Barton to Mixbury cutting	Surface water flow will be collected in land drainage system and discharged to local watercourses. Top of rail level will be <1m above ground level – at risk.
			A4421 Buckingham Road overbridge	Road level will be >1m above 1,000 years return period water level.

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Surface water	Finmere Quarry	High 30 years FMfSW >0.3m	Barton to Mixbury cutting	Small catchment areas and surface water flow will be collected in land drainage system. Top of rail level will be <1m above ground level – at risk.
Surface water	Westbury dry valley	Low 200 years FMfSW <0.3m	Westbury embankment	Top of rail level will be >1m above estimated flood water level.
			Westbury viaduct balancing ponds access	Surface water flow will be collected in land drainage system. Road level will be at existing ground levels – at risk.
Surface water	Turweston Mill tributaries	Low 200 years FMfSW <0.3m	Turweston cutting	Surface water flow will be collected in land drainage system and discharged to local watercourses. Top of rail level will be <1m above ground level – at risk.
		Medium 30 years FMfSW <0.3m	Turweston embankment	Top of rail level will be >1m above estimated flood water level.
			Turweston viaduct balancing ponds access	Surface water flow will be collected in land drainage system. Road level will be at existing ground levels – at risk.
Surface water	Northampton Road	High 30 years FMfSW >0.3m	Brackley south cutting	Surface water flow will be collected in land drainage system and discharged to local watercourses. Top of rail level will be <1m above ground level – at risk.
			Northampton Road overbridge	Road level will be above 1,000 years return period water level.
Surface water	River Great Ouse Tributary at Northampton Road	High 30 years FMfSW >0.3m	Northampton Road overbridge	Road level will be >1m above 1,000 years return period water level.
			Bridleway BD7 permanent diversion	Bridleway may experience flooding with depths up to 1m in the 200 years return period event – at risk.

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Surface water	Radstone south watercourses	Medium 30 years FMfSW <0.3m	Brackley south cutting	Surface water flow will be collected in land drainage system and discharged to local watercourses. Top of rail level will be <1m above ground level, but bunding along both sides will provide protection.
			PRoW AX15 overbridge	Footpath level will be >1m above estimated flood water level.
			Brackley embankment	Top of rail level will be >1m above estimated flood water level.
			Radstone Road overbridge	Road level will be >1m above estimated flood water level.
			Radstone Road attenuation ponds access track	Surface water flow will be collected in land drainage system. Road level will be at existing ground levels – at risk.
Surface water	Radstone central watercourses	Low 200 years FMfSW <0.3m	Brackley north cutting	Surface water flow will be collected in land drainage system and discharged to local watercourses. Top of rail level will be <1m above ground level, but bunding along both sides will provide protection.
Surface water	Radstone north watercourses	High 30 years FMfSW >0.3m	Greatworth south embankment	Top of rail level will be >1m above estimated flood water level.
Groundwater	Finmere Quarry	High High Susceptibility	Barton to Mixbury cutting	Emergent groundwater will be collected in surface water drainage system and discharged to local watercourses. Rail level will be below ground level – at risk.
Groundwater	Deep cuttings – various	N/A	Barton to Mixbury cutting Turweston cutting Brackley south cutting	Emergent groundwater will be collected in surface water drainage system and discharged to local watercourses. Rail level will be below aquifer level – at risk.

7 Flood risk management measures

7.1 Risk of flooding from rivers

7.1.1 The Proposed Scheme will be raised above crossings of fluvial floodplains such that the risk of flooding from this source is less than 0.1%. Therefore the embedded mitigation ensures that there are no instances where the Proposed Scheme will be at significant risk of fluvial flooding, and consequently no specific mitigation is required.

7.1.2 The permanent diversion of Footpaths TUW/7 and BD8 into the area at risk of flooding from the River Great Ouse at Turweston will result in an increased risk of flooding along the two footpaths. A flood hazard analysis taken from the hydraulic model indicates that combined flow depths and velocities are unlikely to create a significant danger to life. The Community section of the ES concludes that the PRoW will not be significantly affected by the permanent diversion (Volume 5: Appendix CM-001-014). Therefore no specific mitigation measures are proposed.

7.1.3 At all Flood Zone crossings replacement floodplain storage will be provided upstream of the Proposed Scheme for all losses in river floodplain storage including viaduct piers, embankments and all associated development. This applies to Mixbury embankment, Westbury viaduct and Turweston viaduct. Dynamic hydraulic effects at Mixbury and Westbury are not expected to be significant, and no specific mitigation is required.

River Great Ouse at Turweston

7.1.4 Conceptual hydraulic modelling of the River Great Ouse undertaken as part of the design process suggests that the Proposed Scheme will result in a maximum afflux of up to 20mm, extending to a maximum distance of 50m upstream of the Turweston viaduct (Volume 5: Appendix WR-004-005). Due to the scale and extent of the effect, together with the beneficial impact of the proposed replacement floodplain storage, it is not considered necessary to provide any additional specific mitigation at the Turweston viaduct.

7.2 Risk of flooding from surface water

7.2.1 The FMfSW shows the extent of flooding due to rainfall that would occur prior to collection of water into streams or designated drainage infrastructure. By collecting the flows from the dry valley into an adequately designed land drainage system, the Proposed Scheme will effectively remove the risk of surface water flooding from the point at which the flow would be intercepted for all return period events up to and including 100 years (>1% annual probability rainfall events) including an allowance for climate change. There is a residual risk of the cut-off drain overtopping in more extreme events.

7.2.2 Measures to manage the risk of flooding from surface water runoff include:

- provision of replacement floodplain storage and surface water attenuation facilities to restrict peak surface water runoff rates to existing greenfield rates;
- culverts have been designed with adequate capacity to convey the 1 in 100

years (1% annual probability) flow including an allowance for climate change; and

- design of culverts with internal 600mm freeboard and 300mm allowance for siltation to minimise the chances of blockage or future capacity restrictions;

7.2.3 There are five locations within the study area where the top of rail level of the Proposed Scheme will be less than 1m above ground level, or a secondary design element lies at or below ground level within an area shown to be at risk of flooding from surface water runoff.

7.2.4 At Newton Purcell, Finmere Quarry, Turweston Mill, Northampton Road and south of Radstone, surface water runoff will be collected into drainage systems and discharged to existing watercourses with all surface water collection elements designed to convey the 1 in 100 years return period (1% annual probability) design flood flow including an allowance for climate change.

7.2.5 All secondary elements such as road and footpath crossings that are within areas at risk from this source will be designed with suitable land drainage infrastructure which will intercept direct runoff.

7.2.6 There will not be any anticipated changes to the risk of flooding from surface water sources as a result of the Proposed Scheme within the Newton Purcell to Brackley area. No specific mitigation will therefore be required.

7.3 Risk of flooding from groundwater

7.3.1 There is a risk of flooding from groundwater within the Barton to Mixbury cutting, Turweston cutting and Brackley south cutting. Groundwater emergence in the cuttings has been taken into account in the design and groundwater will be collected in the surface water drainage system at the base of the cuttings to prevent flooding of the Proposed Scheme.

7.3.2 Groundwater ingress will be managed as part of the design and therefore there will be no significant impact on the risk of flooding from groundwater to third party receptors arising from the Proposed Scheme.

7.4 Risk of flooding from drainage systems

7.4.1 There will be no risk of flooding from drainage systems to the Proposed Scheme, nor any anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. No specific mitigation will therefore be required.

7.5 Risk of flooding from artificial sources

7.5.1 There will be no risk of flooding from artificial sources to the Proposed Scheme, nor any anticipated effects on the risks of flooding from artificial sources within the study area arising from the Proposed Scheme. No specific mitigation will therefore be required.

8 Post-development flood risk assessment

8.1 Local receptors

8.1.1 In addition to the risk of flooding that exists to the Proposed Scheme, there is potential for the Proposed Scheme to affect the risk of flooding to third party receptors by altering flow mechanics for all sources of flooding. All local receptors with a potential flood risk are identified in Section 5 of this report. For the Proposed Scheme to have an impact on a given receptor, the identified pathway for that receptor must be shared by both the subject receptor and the Proposed Scheme, with the result that a number of cases can be excluded immediately. Table 7 summarises the shared pathways between the Proposed Scheme and each receptor and identifies cases where no shared pathway exists.

Table 7: Shared flood risk pathways in CFA14

Local receptor	**Vulnerability classification as per the NPPF**	**Pathway**	**Shared pathway between Proposed Scheme and receptor**
Newton Purcell	More vulnerable	Urban drainage	No shared pathway.
Station Road, Newton Purcell, including Shelswell Arms	More vulnerable	Surface water 30 years - deep	A4421 Buckingham Road overbridge and Barton to Mixbury cutting will be at this location.
Foxley Fields Farm	More vulnerable	Groundwater - moderate	Barton to Mixbury cutting will be 600m to the south-west.
Finmere Quarry (Premier Aggregates Ltd)	Water compatible	Groundwater - very high	Barton to Mixbury cutting will be at this location.
Glebe Farm (Mixbury)	More vulnerable	Surface water 30 years - deep	No shared pathway.
Mixbury village	More vulnerable	Urban drainage	No shared pathway.
Fulwell House	More vulnerable	River flooding Flood Zone 2	Existing railway embankment and culvert will restrict flows upstream of receptor - pathway restricted.
Westbury	More vulnerable	River flooding Flood Zone3 Surface water 30 years - shallow Groundwater - very high	Westbury viaduct is 950m upstream.
Grove Farm	More vulnerable	Surface water 30 years - deep	No shared pathway.
Oatleys Farm	More vulnerable	Surface water 30 years - deep Groundwater - moderate	Bedrock (groundwater) only.

Local receptor	Vulnerability classification as per the NPPF	Pathway	Shared pathway between Proposed Scheme and receptor
Oatleys Hall	More vulnerable	Groundwater - moderate	No shared pathway (groundwater risk from unshared superficial deposits).
"Ballabeg"	More vulnerable	Surface water 30 years - deep	[Receptor to be demolished]
Turweston	More vulnerable	Surface water 30 years - shallow Groundwater - very high	Groundwater only.
Turweston Mill	More vulnerable	River flooding Flood Zone3 Surface water 200 years - shallow Groundwater - very high	Turweston viaduct and embankment will be 450m upstream.
Versions Farm	More vulnerable	Groundwater - moderate	Groundwater only.
Whitfield Sewage Treatment Works (STW)	Less vulnerable	River flooding Flood Zone3 Surface water 200 years - shallow Groundwater - very high	Turweston viaduct will be 1km downstream.
Ilett's Farm	More vulnerable	Surface water 30 years - deep	[Receptor to be demolished]
Illett's Farm buildings off A43	Less vulnerable	Surface water 200 years - shallow	No shared pathway.

8.1.2 There is also the potential for the Proposed Scheme to change the baseline risk of flooding described in Section 6 of this report. Though designed such that the probability of the Proposed Scheme flooding in any given year is less than 1 in 1,000, any change to the baseline risk of flooding could impact on the assessment of flood risk to the Proposed Scheme. All cases of flood risk discussed in Section 6 of this report are therefore reconsidered regardless of the presence or otherwise of third party local receptors.

8.2 Impact on risk of flooding from rivers

Mixbury

Description

8.2.1 The Mixbury embankment is located within the floodplain of the tributary stream at Mixbury, and therefore has the potential to impact the risk of flooding from the watercourse. The Proposed Scheme will cross the watercourse on embankment with a culvert provided to convey the watercourse beneath the Proposed Scheme. There is no available hydraulic model of the stream. The culvert will, however, be designed to

convey the full 1 in 100 years return period (1% annual probability) flood flow including an allowance for climate change and allowances for siltation and blockage.

Local receptors and land use

8.2.2 There are no formal receptors within the floodplain either upstream or downstream of the Mixbury embankment. The land use in the floodplain immediately upstream of the crossing is woodland (Mossycorner Spinney) located within agricultural land belonging to Tibbets Farm.

Assessment of effects

8.2.3 The tributary stream will be conveyed beneath the Proposed Scheme in a 2.1m diameter circular culvert, designed with capacity to convey the estimated 1 in 100 years return period (1% annual probability) design flow including an allowance for climate change of 0.3m^3/s with a 600mm headroom allowance for siltation and blockage within the culvert. The culvert will be 48m long and laid at an approximate gradient of 1 in 60.

8.2.4 Since the culvert will be sized appropriately to convey the full 1 in 100 years return period (1% annual probability) flood flow including an allowance for climate change and allowances for siltation and blockage, no backing up of floodwaters will occur behind the culvert and there will therefore be no increased risk of flooding upstream of the culvert arising from the restriction to flood flows. The Proposed Scheme is located downstream of the disused railway embankment, beneath which the stream is conveyed in an existing culvert. The existing embankment places restrictions on floodplain flow upstream of the Proposed Scheme. This will have the effect of reducing volumes and velocities in the floodplain upstream of the Proposed Scheme further reducing the potential effect of throttling at the Proposed Scheme embankment.

8.2.5 Regardless of the dynamic effects of the Proposed Scheme on the watercourse and floodplain flows, the proposed embankment within the floodplain will occupy flood storage capacity potentially causing displacement of flood waters onto neighbouring land. The loss in floodplain storage will be mitigated through the provision of replacement floodplain storage upstream of the Proposed Scheme. Therefore, there will be no significant impact on the risk of flooding arising from the Proposed Scheme.

River Great Ouse at Westbury

Description

8.2.6 The Proposed Scheme will cross the River Great Ouse to the south-west of Westbury, with the floodplain spanned by the Westbury viaduct. The viaduct will cross the river channel and floodplain at a skew of approximately 20° and will be supported on seven piers located at 37.5m centres.

Local receptors and land use

8.2.7 The southern extent of Westbury, including the school playing fields and leisure facilities, is located within the floodplain approximately 950m downstream of Westbury viaduct. The land in the floodplain surrounding the proposed Westbury viaduct is agricultural and belongs to Westbury Mill.

Assessment of effects

8.2.8 The baseline estimates of maximum flood water levels at the crossing, taken from the Environment Agency hydraulic model, are presented in Table 8. Floodplain flow velocities peak at 0.43m/s in the 1 in 1,000 years return period event (0.1% annual probability) with flows spread relatively evenly across the floodplain extent. Conversely, in the 1 in 100 years return period (1% annual probability) event including an allowance for climate change floodplain flow in the south floodplain is relatively slow at 0.14m/s with higher energy flow velocities in the north floodplain area reaching 0.37m/s. Maximum flood depths in the floodplain are simulated to be 430mm and 370mm respectively.

8.2.9 The minimum top of rail level at the crossing will be 107.3m AOD and the viaduct deck (rail to soffit) will be 4.7m deep resulting in a minimum soffit level of 102.6m AOD. The viaduct deck will clear the maximum predicted flood water level by at least 6m and the viaduct deck itself will therefore not have any impact on the risk of flooding from the River Great Ouse.

8.2.10 The viaduct will be supported on seven piers, each with a 4m by 4m square plan area, located at 37.5m centres. No viaduct piers are proposed within the current channel location of the River Great Ouse and no channel diversion will therefore be required. Due to the relatively low floodplain flow velocities it is unlikely that the viaduct piers will have any significant effect on flood water levels upstream due to dynamic effects.

Table 8: River Great Ouse at Westbury model details

	100 years return period	**100 years return period including climate change**	**1,000 years return period**
Peak channel flow	23.4m^3/s	24.0m^3/s	25.3m^3/s
Peak channel flood level	96.39m AOD	96.44m AOD	96.50m AOD
Peak floodplain flood level	96.51m AOD	96.58m AOD	96.65m AOD

8.2.11 Seven piers will be located within the floodplain with a footprint area of 16m^2 each. The maximum depth of water in the 1 in 100 years return period (1% annual probability) flood including an allowance for climate change is 370mm and the maximum volume of floodplain storage that will be removed is therefore 41m^3. This will be mitigated through the provision of replacement floodplain storage upstream of the Proposed Scheme. Therefore, there will be no significant impact on the risk of flooding arising from the Proposed Scheme. There will be no significant effect on the risk of flooding at Westbury downstream.

River Great Ouse at Turweston

Description

8.2.12 The Proposed Scheme will cross the River Great Ouse immediately upstream of the village of Turweston. Approximately 50m upstream of the Proposed Scheme the river splits to form the mill stream for Turweston Mill some 350m downstream. The level in the millstream is controlled by a weir on the natural channel which is located

approximately 5m upstream of the proposed viaduct. The Proposed Scheme within the floodplain will consist of the two approach embankments (Turweston embankment and Helmdon embankment), and Turweston viaduct which will be a two-span structure supported on a single central pier. The Proposed Scheme will require the mill stream channel to be realigned around the southern approach embankment to allow space for a footpath realignment.

Local receptors and land use

8.2.13 Receptors in the floodplain of the River Great Ouse within the study area are Whitfield sewage treatment works approximately 1km upstream of the Proposed Scheme and Turweston Mill approximately 450m downstream of the Proposed Scheme. The land use within the floodplain around the Turweston viaduct is agricultural with land in the southern floodplain of unknown ownership and land in the northern floodplain belonging to Versions Farm. Approximately 400m upstream of the Proposed Scheme the northern edge of Flood Zone 2 extends into land belonging to Manor Farm.

Assessment of effects

8.2.14 Since the detailed design of the Mill Stream realignment has not yet been undertaken it is not possible to accurately and fully quantify the effect of the Proposed Scheme on the dynamic characteristics of the watercourse. An analysis, however, has been undertaken assuming that the diversion is designed such that there is no change in the conveyance capacity of the diverted channel or any alteration to the extent of overtopping into the natural channel.

8.2.15 The minimum top of rail level at the Turweston viaduct will be 115.2m AOD and the viaduct deck will be 4.7m deep resulting in a minimum soffit of 110.5m AOD. There will be a minimum freeboard of 4.4m for the soffit of the viaduct for the predicted 1 in 1,000 years return period (0.1% annual probability) flood level of 106.1m. The viaduct deck will therefore have no impact on the risk of flooding from the River Great Ouse.

8.2.16 The Turweston and Helmdon embankments will extend into the floodplain flow area on either side of the viaduct. The central pier will also potentially obstruct flood flows. A one-dimensional conceptual hydraulic model of the River Great Ouse at Turweston was created in order to assess the effect of reducing the viaduct span (Volume 5, Appendix WR-004-005). Estimated flood water levels in the baseline case agree well with the Environment Agency model. Flood water levels upstream of the Proposed Scheme are a maximum of 60mm below equivalent levels in the Environment Agency model consistent across all return periods considered. The extents of flooding in the 1 in in 100 years return period (1% annual probability) including climate change flood event and 1 in 20 years return period (5% annual probability) flood event are shown on WR-05-034 and WR-06-034 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

8.2.17 Although the River Great Ouse bifurcates upstream of the Proposed Scheme crossing the Environment Agency model shows very little interaction between the two channels in the vicinity of the Proposed Scheme. As a result, the one-dimensional representation of the river adopted in the design to test the viaduct effect is considered acceptable. The model has therefore been used to quantify the general

effect (afflux) of the proposed viaduct. Results were extracted for the three design return periods, and are presented in Table 9.

Table 9: Estimated flood water levels in the River Great Ouse at Turweston

	1% annual probability	1% annual probability including climate change allowance	0.1% annual probability
Baseline	105.85m AOD	105.91m AOD	106.03m AOD
Future	105.86m AOD	105.92m AOD	106.05m AOD
Maximum afflux	10mm	10mm	20mm
Maximum influence	50m upstream of the viaduct		

8.2.18 The model shows that the viaduct will potentially cause a maximum increase in flood water levels upstream of the Proposed Scheme of 20mm to a maximum distance of 50m. Due to the steep valley sides this increase is unlikely to materially increase the extents or risks of flooding on the agricultural land within this area.

8.2.19 Since the purpose of the conceptual model of the River Great Ouse was to assess the feasibility of reducing the viaduct width, the viaduct was modelled as 50m wide. The central pier was not included in the model. Applying a 50m wide viaduct will result in potential overestimates of the effect of the viaduct on upstream water levels compared with the final design of an 80m wide viaduct due to increased flood flow restriction.

8.2.20 The modelled viaduct is 30m narrower than the proposed viaduct with the abutments reaching to the top-of-bank of each watercourse where flow velocities will be highest. It is unlikely that the 4m wide central pier will have an effect on flood water levels in excess of the effect of narrowing the viaduct by 30m which would obstruct a significantly greater flow area. Consequently, it is reasonable to assume that the modelled effect of the viaduct represents an overestimate of the potential afflux that could arise from the Proposed Scheme.

8.2.21 Regardless of the impact of the viaduct abutments and piers on the dynamic characteristics of the floodplain the built volume of the Turweston and Helmdon embankment and the viaduct abutments within the floodplain will cause displacement of flood water through the removal of floodplain storage. This will be mitigated through the provision of replacement floodplain storage upstream of the Proposed Scheme. There will, therefore, be no significant impact on the risk of flooding arising from the Proposed Scheme. There will be no significant effect on the risk of flooding at Turweston Mill or Whitfield Sewage Treatment Works.

8.3 Impact on risk of flooding from surface water

8.3.1 There are areas of flood risk shown on the FMfSW associated with the River Great Ouse and the Mixbury tributary stream. In all cases the extents of flooding are within the extents of flooding from rivers for the watercourses and, since flooding from direct surface water runoff occurs early in any given rainfall event, is likely to have receded prior to the onset of any significant flooding from the watercourses. On this

basis there is unlikely to be any significant cumulative effect due to combined flooding from direct runoff and from the watercourse that would not already be accounted for in the flood risk from rivers analysis discussed previously. As a result, flood risk from the rivers would be the dominant source of flood risk to the line with additional effects from direct runoff likely to be negligible and therefore not assessed further in this section.

Newton Purcell

8.3.2 Close to the southern extent of CFA14 near to Newton Purcell, the Proposed Scheme will pass alongside the valley of a tributary stream to the Padbury Brook crossing the line of the watercourse at two locations. Due to the presence of the existing railway embankment the Proposed Scheme lies only partially within the area shown to be at risk of shallow flooding (100mm to 300mm depth) in the 1 in 30 years return period (3.3% annual probability) event and watercourse culverts are already in place. The Proposed Scheme will, however, be in cutting through the area. The valley splits at Station Road with watercourses and associated surface water risk areas on both sides of the Proposed Scheme. The A4421 Buckingham Road overbridge will cross both of these streams and areas of risk. Noise barriers along the west side of the Proposed Scheme north of Station Road will also cross the watercourse and risk area.

8.3.3 Overland flows are to be collected into land drainage in this area including diversions of the existing watercourses along both sides of the Proposed Scheme before passing to the east side of the Proposed Scheme close to the current embankment culvert in a drop inlet culvert (1350mm diameter). The culvert will be designed to convey the estimated 1 in 100 years return period (1% annual probability) flood flow including an allowance for climate change, siltation and blockage. The diverted watercourse channels will be designed with sufficient capacity for the estimated 1 in 100 years return period (1% annual probability) flood flow including an allowance for climate change. As a result, there will be no significant increase in the flood risk upstream of the Proposed Scheme. Any potential reductions in floodwater conveyance time within the vicinity of the Proposed Scheme are likely to be negligible.

8.3.4 The A4421 Buckingham Road overbridge will cross both arms of the tributary stream and associated valleys. The streams will be conveyed beneath the overbridge embankments in 1200mm precast concrete box culverts designed to adequately convey the 1 in 100 years return period (1% annual probability) return period flood flows including allowances for climate change, siltation and blockage. As a result, there will be no significant increase in the flood risk upstream of the Proposed Scheme. Any potential reductions in floodwater conveyance time within the vicinity of the Proposed Scheme are likely to be negligible.

Finmere Quarry

8.3.5 The scattered areas around Finmere Quarry shown on the FMfSW to be at risk of deep (>300mm) surface water ponding during both the 1 in 200 years return period (0.5% annual probability) and 1 in 30 years return period (3.3% annual probability) rainfall events are likely to arise from small, localised catchments. By collecting and discharging surface water in the formal land drainage system associated with the Proposed Scheme the potential for flooding from this source will be reduced or

removed entirely. It is likely that surface water volumes will be very small and collection of ponded surface water is unlikely to significantly affect the risk of flooding to downstream watercourses, especially since surface water will be passed through attenuation features prior to discharge. Consequently, the Proposed Scheme will not have any significant effect on the risk of flooding from surface water at this location.

Westbury dry valley

8.3.6 Approximately 400m south of the Westbury viaduct, the Proposed Scheme will cross a dry valley that passes in a north-easterly direction towards the River Great Ouse. The base of the dry valley is shown to be at risk of shallow (<0.3m depth) surface water flooding in the 1 in 200 years return period (0.5% annual probability) rainfall event. Ponding occurs behind the dismantled railway embankment which disrupts flood flows towards the base of the Great Ouse valley. The overland flows will be intercepted by the proposed land drainage which will be designed with sufficient capacity to contain the 1 in 100 years return period (1% annual probability) design flood including an allowance for climate change and discharged to the River Great Ouse via an attenuation pond at Westbury viaduct. There will therefore be no significant effect on the risk of flooding from this source.

Turweston Mill tributaries

8.3.7 To the north of Turweston, the Proposed Scheme will cross two dry valleys which flow from east to west towards the floodplain of the River Great Ouse. The southern dry valley joins the floodplain at Turweston Mill and there is a narrow band at risk of shallow (100mm to 300mm in depth) flooding in the 1 in 200 years return period (0.5% annual probability) rainfall event. The northern dry valley joins the floodplain of the River Great Ouse immediately downstream of the Proposed Scheme with areas shown on the FMfSW to be at risk of shallow (100mm to 300mm in depth) flooding in both the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events.

8.3.8 Surface water runoff will be collected within the land drainage of the Proposed Scheme along the east side discharging via an attenuation pond to the River Great Ouse upstream of Turweston viaduct. All land drainage elements will be designed with sufficient capacity to convey the 1 in 100 years return period (1% annual probability) rainfall event including allowances for climate change, blockage and siltation. Since the land drainage will be designed to the 1 in 100 years return period (1% annual probability) rainfall event including an allowance for climate change there will be no significant backing up of flows. Surface water will discharge to the River Great Ouse via an attenuation pond and there will be no significant effect on the risk of flooding in downstream watercourses. There will be no significant effect arising from the Proposed Scheme on the risk of flooding from this source.

Northampton Road

8.3.9 The Proposed Scheme will cross a dry valley at Ilett's Farm on the north side of the A43 Northampton Road. The raised A43 road embankment results in ponding on the upstream side, shown as areas of deep (greater than 300mm) flooding on the FMfSW in both the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events. Surface water runoff will be

collected within the land drainage of the Proposed Scheme along both sides of the Proposed Scheme. The east side land drainage will discharge directly to the River Great Ouse upstream of Turweston viaduct, with the west side land drainage discharging via an attenuation pond to the River Great Ouse downstream of Turweston viaduct.

8.3.10 All land drainage elements will be designed with sufficient capacity to convey the 1 in 100 year return period (1% annual probability) rainfall event including allowances for climate change, blockage and siltation and there will consequently be no additional risk of flooding as a result of insufficient drainage capacity. Although there is potential for the east side land drainage to reduce conveyance times to the River Great Ouse due to the direct outfall, expected flow rates are low, and likely to be negligible in the context of the overall risk of flooding from the River Great Ouse. Consequently, there will be no significant effect on the risk of flooding from this source.

8.3.11 The southern approach embankment of the Northampton Road overbridge will cross a culverted tributary stream of the River Great Ouse at its far southern extent. The valley is relatively steep sided, however there is a significant area along the base of the valley shown to be at risk of deep (greater than 300mm) flooding in both the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events, the severity compounded by backing up behind the culvert beneath the existing Northampton Road. The current road embankment will remain following development with a culvert provided to convey flows to the existing culvert beneath Northampton Road. The effect of the Proposed Scheme on the risk of surface water flooding upstream and downstream of Northampton Road will therefore be negligible.

Radstone south watercourses

8.3.12 South of Radstone, the Proposed Scheme will cross a watercourse and dry valley with associated areas at risk of shallow (100mm to 300mm) surface water flooding shown on the FMfSW in both the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events. Direct surface water runoff within the dry valley will be collected into the proposed land drainage and discharged to the northern watercourse via an attenuation feature. The watercourse will be conveyed beneath the Proposed Scheme in a 1.8m square box culvert approximately 35m long laid at a gradient of 1 in 500. All land drainage infrastructure and surface water elements will be designed with sufficient capacity to convey the 1 in 100 years return period (1% annual probability) rainfall event including an allowance for climate change, siltation and blockage. As a result, there will be no significant increase in the flood risk upstream of the Proposed Scheme. Any potential reductions in floodwater conveyance time within the vicinity of the Proposed Scheme will be negligible and consequently will not significantly affect the risk of flooding arising from downstream sources such as the Radstone Brook.

Radstone central watercourse

8.3.13 To the north-west of Radstone, the Proposed Scheme will cross a further tributary of the Radstone Brook, close to the 'issues' location. The FMfSW shows a risk of surface water flooding in the 1 in 200 years return period (0.5% annual probability) rainfall

event, of between 100mm and 300mm depth. The watercourse will be diverted north to the watercourse on the boundary of CFA15. All surface water runoff will be collected into the diverted watercourse and discharged via an attenuation feature. The land drainage infrastructure will be designed with sufficient capacity to convey the 1 in 100 years return period (1% annual probability) rainfall event including an allowance for climate change, siltation and blockage. As a result, there will be no significant increase in the flood risk upstream of the Proposed Scheme.

Radstone north watercourses

8.3.14 At the northern extent of the study area, along the boundary with CFA15, the Proposed Scheme will cross a small watercourse and dry valley to the north. The FMfSW shows surface water flooding greater than 300mm deep in the 1 in 30 years return period (3.3% annual probability) rainfall event at the watercourse crossing.

8.3.15 The Proposed Scheme will be on a low embankment at the watercourse crossing, and at grade across the dry valley. Overland flow in the dry valley on both sides of the Proposed Scheme will be collected and discharged to the watercourse which will be conveyed beneath the Proposed Scheme in a 1500mm diameter culvert. This culvert will be designed to convey a flow of $2.01m^3/s$ which is the calculated combined peak 1 in 100 years return period (1% annual probability) flow including an allowance for climate change, from this watercourse and the tributary from the south.

8.3.16 In the baseline scenario, the dry valley and watercourse combine approximately 40m downstream of the Proposed Scheme. By combining flows upstream of the Proposed Scheme a slight increase in flows within the watercourse channel for this 40m stretch could potentially lead to a slightly increased risk of channel capacity exceedance. Due to the scale of flows however, any such increase will be negligible. Likewise, potential reductions in floodwater conveyance time within the vicinity of the Proposed Scheme are likely to be negligible and consequently will not significantly affect the risk of flooding arising from downstream sources such as the Radstone Brook.

8.4 Impact on risk of flooding from groundwater

8.4.1 As described in Volume 5: Appendix WR-002-014 there are a number of deep cuttings proposed within CFA14 which have the potential to intercept groundwater flows. Design elements within CFA14 that may affect the risk of flooding due to below-ground construction within water-bearing strata, together with a summary of the expected effects of the Proposed Scheme are covered in Section 8.4.2 to 8.4.6.

8.4.2 The Barton to Mixbury cutting will pass through the Cornbrash Limestone and Forest Marble formations. The cutting will be shallow in the context of the aquifer depth and is therefore not expected to significantly affect groundwater levels. Intercepted groundwater will be returned to local watercourses to avoid affecting watercourse flow rates.

8.4.3 The Mixbury cutting will pass through the White Limestone Formation. Since any groundwater intercepted by the cutting will be returned to local watercourses to avoid affecting watercourse flow rates, it is unlikely that there will be significant local

increases in groundwater levels across the aquifer which could lead to increased risks of groundwater flooding.

8.4.4 The Turweston cutting will pass through the White Limestone Formation, and where it is deepest, will reach to the base of the Horsehay Sandstone Formation. Groundwater flows are presumed to be towards the River Great Ouse. Since any groundwater intercepted by the cutting will be returned to ground or local watercourses via attenuation ponds to avoid affecting watercourse flow rates, it is unlikely that there will be significant local increases in groundwater levels across the aquifer which could lead to increased risks of groundwater flooding.

8.4.5 The Brackley south and Brackley north cuttings will pass through the Blisworth and Taynton Limestone Formations. The Great Oolite is a relatively free draining formation and the cutting is considered unlikely to significantly affect groundwater levels in the area.

8.4.6 The Proposed Scheme will not have any significant effect on the risk of flooding from groundwater arising from the bedrock aquifers within the study area. The Proposed Scheme will not be in cutting where it will intersect with areas of water-bearing superficial strata and there will consequently be no significant effect on the risk of flooding from groundwater arising from superficial deposits.

8.5 Impact on risk of flooding from drainage systems

8.5.1 The Proposed Scheme will not pass through any urban areas for the full extent within CFA14. All highway crossings required will be diverted or redesigned as bridges or underpasses with the exception of those that will be crossed on viaduct which will remain unchanged. Highway drainage for all new or realigned roads will be designed in accordance with the relevant design guides and regulations and consequently no increase in the risk of flooding arising from overloaded highway drains is anticipated.

8.6 Impact on risk of flooding from artificial sources

8.6.1 The Proposed Scheme will not cross any areas shown on the Environment Agency RIM to be at risk of flooding in the event of impounded reservoir failure. Consequently, the Proposed Scheme will not affect the risk of flooding from this source within CFA14.

8.7 Summary of potential impacts on flood risk

Table 10: Summary of potential flood risk effect in CFA14

Receptor	Vulnerability classification	Pathway	Effects
General Proposed Scheme	N/A	Fluvial	Minor afflux and volume displacement at Mixbury and Turweston River Great Ouse crossings. Displacement to be offset by replacement floodplain storage.
		Pluvial	Potential minor effects due to collection of overland flows into formal drainage systems.
		Groundwater	No effects expected.

Receptor	Vulnerability classification	Pathway	Effects
		Drainage Systems	No effects expected.
		Artificial sources	No effects expected.
Station Road, Newton Purcell, including Shelswell Arms	More vulnerable	Surface water 30 years - deep	Surface water will be collected into Proposed Scheme drainage and no adverse effects on the risk of flooding are expected.
Foxley Fields Farm	More vulnerable	Groundwater - moderate	No effects are expected on the risk of groundwater flooding to any receptors.
Finmere Quarry (Premier Aggregates Ltd)	Water compatible	Groundwater - very high	No effects are expected on the risk of groundwater flooding to any receptors.
Westbury	More vulnerable	River flooding Flood Zone3 Groundwater - very high	Effects of Westbury viaduct will be localised and mitigated. There will be no impact downstream at Westbury village. No effects are expected on the risk of groundwater flooding to any receptors.
Oatleys Farm	More vulnerable	Groundwater - moderate	No effects are expected on the risk of groundwater flooding to any receptors.
Turweston village	More vulnerable	Groundwater - very high	No effects are expected on the risk of groundwater flooding to any receptors.
Turweston Mill	More vulnerable	River flooding Flood Zone3 Groundwater - very high	Effects of Turweston viaduct will be localised and mitigated. There will be no impact downstream at Turweston Mill. No effects are expected on the risk of groundwater flooding to any receptors.
Versions Farm	More vulnerable	Groundwater - moderate	No effects are expected on the risk of groundwater flooding to any receptors.
Whitfield STW	Less vulnerable	River flooding Flood Zone3 Groundwater - very high	Effects of Turweston viaduct will be localised and mitigated. There will be no impact upstream at Whitfield STW. No effects are expected on the risk of groundwater flooding to any receptors.

9 Conclusions

9.1 Summary

9.1.1 The Proposed Scheme within CFA14 extends south-east to north-west from the Buckinghamshire-Oxfordshire county boundary near Newton Purcell to north of Brackley and West of Radstone. The study area encompasses all areas within 1km of the Proposed Scheme, which includes areas at risk of flooding from the following sources:

- areas at risk of river flooding from the River Great Ouse and a tributary stream near Mixbury;
- areas at risk of surface water flooding near Newton Purcell, Finmere Quarry, Westbury, Turweston Mill, Northampton Road and Radstone; and
- areas with a susceptibility to groundwater flooding at Finmere Quarry, and areas of deep cutting through water-bearing bedrock strata.

9.1.2 The Proposed Scheme will be at least 1m above design flood water levels within all areas at risk of flooding from river sources. Residual risks from these sources will be negligible. There are some areas at risk of flooding from direct surface water runoff where the Proposed Scheme will be less than 1m above ground levels, resulting in a need for greater consideration of the risk of flooding when designing surface water management schemes and watercourse crossings. There is one instance where the Proposed Scheme will be in cutting through an area with a susceptibility to groundwater emergence, as well as some deep cuttings through water-bearing bedrock strata. At these locations, flooding from groundwater will be collected into the track drainage of the Proposed Scheme. Design standards are such that no flooding of the Proposed Scheme will be expected under normal operating conditions.

9.1.3 The dominant land use within the study area is agriculture. Excluding areas of farmland immediately adjacent to the Proposed Scheme at Turweston there will be no off-site receptors that will be significantly affected by the Proposed Scheme. In order to prevent general impacts on flood risk and river morphology resulting from the Proposed Scheme, the following mitigation will be included:

- provision of replacement floodplain storage to prevent an increase in the risk of river flooding;
- provision of replacement floodplain storage and surface water balancing ponds to maintain existing peak runoff rates and volumes;
- design of culverts with 600mm internal headroom and allowances for siltation (300mm) to minimise the chances of blockage or future capacity restrictions; and
- inclusion of a 30% allowance for climate change on all design rainfall events and minor watercourses and 20% on all river flows where a Flood Zone is present.

9.1.4 There will be no significant increase in the risk of flooding to third party receptors arising from the Proposed Scheme.

9.2 Residual flood risks to Proposed Scheme

9.2.1 Residual flood risks arise in situations that are not included in standard design scenarios; for example when a culvert becomes blocked causing flooding upstream. All design is generally undertaken assuming that existing infrastructure is functioning under normal conditions. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

Residual flood risks from rivers

Mixbury

9.2.2 There are two existing crossings of the tributary stream upstream of the Proposed Scheme. Failure of any restrictions upstream of the Proposed Scheme such as collapsing embankments could potentially increase the risk of flooding to the Proposed Scheme. All surface water elements, however, are designed to convey the full design flow, without reference to upstream flow restrictions, and as a consequence, the capacity of the culvert should not be exceeded in such an event, and the overall risk of flooding will not increase. Sudden failures could result in higher flood peaks than those calculated. The Proposed Scheme, however, will be at least 1m above the existing ground levels, and any residual risk to the Proposed Scheme will therefore be negligible. There are no significant hydraulic structures downstream of the Proposed Scheme that will create additional residual risks to the Proposed Scheme.

River Great Ouse at Westbury

9.2.3 There are two existing embankment crossings of the River Great Ouse upstream of proposed viaduct at Westbury. Failure of any restrictions upstream of the Proposed Scheme such as collapsing embankments could potentially increase the risk of flooding to the Proposed Scheme. The viaduct will be higher than 10m above the floodplain, and the residual risks of flooding over and above the design event will not be significant.

River Great Ouse at Turweston

9.2.4 There are no significant hydraulic structures within the vicinity of the route that will create additional residual risks to the Proposed Scheme.

Residual flood risks from surface water and minor watercourses

9.2.5 All culverts within the Proposed Scheme are designed with minimum internal headroom of 600mm above the design flood water level to minimise the risk of blockage. There is therefore not expected to be any significant increased risk of flooding at minor watercourses and dry valley crossings arising from potential blockage of culverts.

9.2.6 At Newton Purcell, Northampton Road, Radstone South, the Proposed Scheme will cross watercourses or dry valleys close to existing culverts and road embankments. At all three locations, however, the relevant features will be reconfigured as part of the

Proposed Scheme, with all elements subject to the minimum design standards, that is, including minimum internal headroom of 600mm to minimise the risk of blockage. There is therefore not expected to be any significant increased risk of flooding at minor watercourses and dry valley crossings arising from potential blockage of existing culverts.

9.2.7 There are no further watercourse crossings within CFA14 where significant hydraulic structures exist within a reasonable hydraulic distance either upstream or downstream, which will create significant additional risks of flooding to the Proposed Scheme due to blockage or failure.

Residual flood risks from groundwater

9.2.8 Groundwater levels rise and fall relatively slowly, and for any change to occur in the risk of flooding from this source, below ground intervention is required. The risk of flooding from groundwater already considered therefore presents an absolute risk, and there are no significant residual risks arising from this source.

Residual flood risks from drainage systems and artificial sources

9.2.9 There are no areas within CFA14 where a significant risk of flooding exists from drainage systems or artificial sources. Consequently, there are no expected residual risks from these sources.

9.3 Residual effects of the Proposed Scheme on flood risk

9.3.1 Following mitigation for impacts on the risk of flooding arising from the Proposed Scheme, there will be slight residual effects on the risk of flooding due to changes to geometry, floodplain flow characteristics and fluvial morphology at Mixbury, Westbury viaduct and Turweston viaduct. Such effects will be limited to the reshaping of floodplain extents arising from replacement floodplain storage and watercourse diversions, with no overall residual effects on additional third party receptors.

9.3.2 All culverts within the Proposed Scheme are designed to convey the 1 in 100 year (1% annual probability) flow including an allowance for climate change with minimum internal headroom of 300mm above the design flood water level to minimise the risk of blockage. Consequently, there will be a negligible increase in upstream residual flood risks arising from the introduction of culverts within the Proposed Scheme.

9.4 Compliance with local planning policy

9.4.1 The Proposed Scheme includes an allowance for future increases in the risk of flooding as a result of climate change by adding a 20% increase to design river flows and a 30% increase to rainfall intensities and flows in minor watercourses as recommended in the NPPF Technical Guidance document. SuDS, in the form of balancing ponds and swales, as well as the creation of open channel land drainage, are used throughout the design. Several local planning policy documents state that all development proposals require detailed drainage design and the use of SuDS to reduce the rate and volume of surface water. The Proposed Scheme will therefore be in compliance with the AVDC SFRA, the Aylesbury Vale Water Cycle Strategy, the

West Northamptonshire Water Cycle Study, the Buckinghamshire and Northamptonshire LFRMS, and the CDC Local Plan.

9.4.2 The location of the Proposed Scheme within areas of flood risk, and the inevitable losses in natural floodplain capacity, is at variance with the general aims of the Cherwell Local Plan Policy EN14. There is, however, no practical way to avoid a certain amount of floodplain flow obstruction, as a result of the nature of the Proposed Scheme. The Cherwell and West Oxfordshire joint SFRA aims to manage future flood risk by promotion of the protection of floodplains from development, however states that where floodplain development is inevitable and additional floodplain storage should be provided. The Cherwell and West Oxfordshire joint SFRA recommends that strategic infrastructure is located within areas with the lowest risk of flooding.

10 References

Aylesbury Vale District Council (2012), *Aylesbury Vale Strategic Flood Risk Assessment;* Aylesbury Vale District Council (Revised from: Royal Haskoning (2007), *Aylesbury Vale SFRA*; Aylesbury Vale District Council).

Aylesbury Vale District Council (2012), *Aylesbury Vale Level 1 Strategic Flood Risk Assessment for The Vale of Aylesbury Plan.*

Buckinghamshire County Council (2013), *Buckinghamshire County Council Local Flood Risk Management Strategy 2013 – 2018.*

Cherwell District Council (2011), *Cherwell Local Plan.*

Department for Communities and Local Government (2012), *National Planning Policy Framework.*

Department for Communities and Local Government (2012), *National Planning Policy Framework Technical Guidance.*

Environment Agency (2011), *Great Ouse Region Catchment Flood Management Plan.*

Flood Risk Regulations 2009 (SI 2009 No. 3042), London, Her Majesty's Stationery Office.

FD2321/TR2 Table 3.1 (Department for Environment, Food and Rural Affairs R&D Outputs: Flood Risks to People Phase 2 – Guidance Paper, Guidance Note 3)

Halcrow (2012), *Aylesbury Vale Water Cycle Strategy.*

Halcrow (2009), *West Northamptonshire Water Cycle Study.*

Jacobs (2011), *Buckinghamshire County Council Preliminary Flood Risk Assessment.*

Jacobs (2008), *Cherwell District Strategic Flood Risk Assessment.*

JBA (2011), *Oxfordshire Preliminary Flood Risk Assessment.*

Northamptonshire County Council (2012), *Northamptonshire Local Flood Risk Management Strategy.*

Northamptonshire County Council (2011), *Northamptonshire Preliminary Flood Risk Assessment*.

Scott Wilson (2009), *West Northamptonshire Strategic Flood Risk Assessment.*

West Northamptonshire Joint Planning Unit (2013), *West Northamptonshire Joint Core Strategy.*